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I Just Ran 24.000 Regressions: Evidence on Financial Contagion in the Euro Area

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Abstract

Using daily data from 2002-2020, this study tests for contagion in the Eurozone using a binary stress indicator for extreme occurrences of sovereign bond yields. Contagion is evaluated by the significance of a country's stress indicator in explaining other countries' stress periods, controlling for *push* and *pull* factors in order to disentangle contagion from interdependence, and following Sala-i-Martin (1997) to obtain robust results. We find evidence of contagion, albeit diverging from the well-documented Eurozone core-periphery dichotomy, with relationships nor mutual nor exclusive. We find that Greece's impact is not as widespread as expected, while Italy's gains traction across crises, alluding to "wake-up call" contagion.

Keywords: Financial Crises, Contagion, Financial Stress, Sovereign Bond Markets, Euro-Area.

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1 Introduction

When, in late 2009, news hit that Greece had been underreporting its budget deficit, hardly anyone could predict the severe tensions that would emerge in global financial markets. By December 2009, all three main rating agencies (Moody's, Fitch and Standard & Poor's) had downgraded Greek debt, raising the yields on its sovereign bonds and effectively shutting it out of financial markets. As perceptions of insolvency persisted even after EU/IMF rescue packages, countries with perceived weak macroeconomic and fiscal fundamentals such as Portugal, Spain, Italy and Ireland saw their credit ratings successively downgraded and suffered mass sell-offs of their sovereign bonds, stressing the sovereign-bond markets and causing a tacit re-emergence of significant spreads against the German Bund after almost a decade of a certain apparent desensitization of markets to these countries' fiscal resources. Over a decade later, a full recovery had not been achieved and market sentiment was still often biased against these countries.

It is unarguable that the sovereign debt crisis exposed a number of architectural flaws in the EMU's structure such as the lack of a common lender of last resort policy, the large interdependency of financial and banking systems or its apparent inability to manage common shocks, especially those asynchronous (Shambaugh, 2012). Additionally, it has resuscitated the interest on financial contagion, making it one of the epicenters of Euro-related concerns and reigniting a movement for literature on this topic. The rash and simultaneous rise in borrowing costs across the EMU's periphery following the onset of Greek instability has become a prolific subject of academic discussion where notable works such as De Santis (2012) and Mink and de Haan (2013) present convincing evidence on the existence of contagion in financial markets by studying the volatility of sovereign yields or credit default swaps within the Euro area.

This paper aims to contribute to existing literature by testing the bilateral contagious links between 12 EMU countries under periods of financial stress. In the absence of a consensual

definition of financial stress, episodes of tension are not specified *a priori* through other sources that date crises episodes. Rather, using daily data from 2002 to 2020, a binary indicator variable for financial stress in each country's sovereign bond market is constructed following Calvo et al. (2004)'s methodology for the identification of extreme periods. The presence of bilateral contagion is thus assessed by the statistical significance of a given country's stress indicator in being able to explain the stress felt in other countries, controlling for both common (*push* factors, such as external financing conditions) and country-specific determinants (*pull* factors, representative of economic fundamentals), in an attempt to distinguish what constitutes contagion from interdependence. The high correlation between sovereign yields within the EMU raises identification concerns, and as such, variables representative of other countries' stress cannot be appended all at once. Instead, following Sala-i-Martin (1997), they are included in combinations of three, leading this paper to run thousands of regressions to obtain collinearity-robust results. By working outside the scope of correlation analysis, this study offers its contribution by presenting a careful analysis on the direction of contagion as opposed to just testing for its presence, thus distinguishing between the "contagious" country and the country that feels its penalties.

The rest of the paper proceeds as follows. Section 2 reviews the existing body of literature. Section 3 introduces the model specification for identifying financial stress and contagion, while Section 4 clarifies the data used. Section 5 presents empirical results and Section 6 concludes.

2 Literature Review

Literature on financial contagion is extensive, yet not unanimous. There is a startling amount of disagreement among economists on how to best define contagion, and consequently, how to identify it and measure it empirically (Gómez-Puig and Sosvilla-Rivero, 2014). In broad terms, the concept often refers to excess spillovers of financial turmoil from one market to another, beyond what can be explained by market fundamentals (see *inter alia*, Eichengreen et al., 1996, Bekaert et al., 2005 and Constâncio, 2012). Karolyi and Stulz (1996), for instance, state that

“contagion effects result when enthusiasm for stocks in one market brings about enthusiasm for stocks in other markets, regardless of the evolution of market fundamentals”. Kaminsky et al. (2003) suggest it is a chain reaction response of other countries to certain financial events. This is also denoted as herding behaviour or “pure" contagion, that is, contagion arising from self-fulfilling panic and loss of confidence among investors because periods of market uncertainty rely on more than the changes in risk-pricing of fundamentals (Ludwig, 2014), leading to the alarming possibility that some markets are being punished for crises they had little to do with.

A growing number of authors have offered their contribution to a potential definition. As a result of recent events, the relative importance of the role of fundamentals as a channel through which shocks are transmitted has come into light. This was highlighted during the sovereign debt crisis and gave rise to another strand of the literature on contagion, one that takes place through fundamental links rather than beyond them, the so called “wake-up call” or fundamentals contagion, coined by Goldstein (1998) and presented in Goldstein et al. (2000) and Bekaert et al. (2014). It argues that a crisis in a given country may be responsible for providing new information that leads financial markets to reassess their perceptions about countries with similar characteristics, changing the way fundamentals are priced and spreading the crisis across borders.

Most definitions, however, hinge on a number of difficulties in terms of interpretation. A common factor that drives up volatility in several markets is likely to increase the magnitude of co-movements between these countries as a result of interdependence and not contagion *per se*. In a pivotal work, Forbes and Rigobon (2002) address this issue. They outline contagion as "a significant increase in cross-market linkages after a shock to one country" and present a test to compare cross-country correlations between tranquil and turbulent periods, claiming that only a substantial shift in volatility-adjusted co-movements may be identified as contagion, in order to exclude the possibility of capturing solely interdependence. Nevertheless, Corsetti et al. (2002) point that there is no single interpretation of interdependence, and as such, no claim of contagion

can be considered unequivocal. There also remains a lot of discussion on what constitutes a global shock and which should qualify as contagion. The chain reaction following the collapse of Lehman Brothers is often regarded as contagion, even if this was a global shock resulting from existing fundamental links between countries' banking systems (Buchholz and Tonzer, 2013).

On the grounds of inherent identification problems, this diversity of definitions is also reflected through a panoply of different methodologies developed across time. Naturally, some of these have gained more traction than others, and thus offered more prolific contributions, as is the case of correlation analysis. In a pioneering work, King and Wadhwani (1990) search for a higher correlation between the U.S., U.K. and Japan during the 1987 crash in world stock markets. Eichengreen et al. (1996), however, offer their input through probability analysis. By constructing a binary indicator for exchange rate market pressure and estimating a probit model using macroeconomic fundamentals as explanatory variables, they were able to prove that a currency crisis in a given country raised the likelihood of a speculative attack in others.

While there are some notable exceptions (e.g. Eichengreen et al., 1996), a sizable proportion of the literature studies the presence of contagion using sovereign bond yields and/or credit default swaps, especially so after the onset of the sovereign debt crisis. Such is the case of Beirne and Fratzscher (2013), who use counterfactual analysis to prove there would have been less convergence in sovereign yields between EMU countries in the pre-crisis period if financial markets had priced fundamentals in 1999-2007 the same way they did in 2008-2011. Manasse and Zavalloni (2013) find that about 54 to 80% of the change in CDS spreads was explained by market fundamentals. Similarly, Favero and Missale (2012) and Bai et al. (2012) find evidence that yields are mostly driven by fiscal fundamentals in periods of risk aversion. Missio and Watzka (2011) and Mink and de Haan (2013) find that select news reports about Greece's public finances, credit rating announcements and the willingness of other countries to provide financial support contribute to abnormal returns not only on international banks' stock prices, but also on

the yields of countries like Portugal, Spain and Ireland. Analogously, Arghyrou and Kontonikas (2012) and Afonso et al. (2012) find evidence of contagion from the deterioration of Greek fundamentals to the vast majority of the Euro area. Further papers can be cited as pervasive evidence for "wake-up call" contagion, showing that there was a period of benign neglect of fiscal fundamentals in the years preceding the crisis (see, *inter alia*, Aizenman et al., 2013).

While the existing body of work on contagion in the Eurozone bond market is comprehensive, the present study aims to offer its contribution by applying Sala-i-Martin (1997)'s approach for the identification of robust determinants in order to identify and describe countries' bilateral contagious links occurring under periods of financial stress. By emphasizing the direction of contagion and assessing it on both ends, it is possible to obtain a clearer understanding of how contagion is actually channelled and what countries are affected as a result. Moreover, by *a priori* controlling for *push* factors, this paper is able to disentangle, to some extent, what can be qualified as contagion and not interdependence, a common problem in the literature.

3 Methodology

3.1 Constructing a Financial Stress Indicator

Identifying contagion in the Euro area requires the definition of periods of financial stress. Sovereign bond yield differentials against Germany are often used to reflect the default risk of a given country, as they represent the premia required by investors to accept sovereign debt in comparison to a German Bund of equal maturity. However, yields on sovereign bonds within the EMU are extremely correlated amongst each other (Panel A on Table A.1 of the Appendix). A high correlation between explanatory variables could lead to unstable parameter estimates with inflated variances and standard errors, which undermines the ability to identify their importance in the model (Stevens, 2002). Moreover, following abundant empirical research, linear econometric models such as simple linear regressions may not be sufficiently informative when it comes to the extreme occurrences of sovereign yields. Drawing inference can lead to conflicting results as

financial stress occurs only seldom but still has a substantial disruptive impact (Grimaldi, 2010).

To overcome these problems, our estimation exercise is based on the construction of an indicator that signals times of financial tension in sovereign debt markets. Following Calvo et al. (2004), an episode of financial stress is identified with the following criteria: (i) it must contain at least one observation (one day) where the differential between the sovereign's yield vis-à-vis Germany lies at least two standard deviations above a rolling mean calculated over the previous 60 days and (ii) the episode starts once the differential surpasses the historical mean by one standard deviation and it ends once it reverts back to the mean, crossing below the one standard deviation mark once again. This creates a binary variable that takes value one if the country is experiencing a period of stress and zero otherwise. This is the model's dependent variable.

One must acknowledge this indicator's limitations. By using yield spreads vis-à-vis Germany, a stress episode as here defined is capturing impacts from both the country under analysis and Germany. A rise in Portuguese yield constitutes a period of stress in Portugal, as does a decrease in German yield, *ceteris paribus*. Additionally, periods of optimism in market sentiment often result in a sell-off of sovereign bonds, as investors prefer riskier assets that offer more return.

3.2 Identifying the Determinants of Financial Stress: Panel Analysis

Before turning to the assessment of contagious links, a panel data approach is employed for the identification of the other drivers of financial stress. The concept of contagion commonly relates to the propagation of shocks between countries beyond what economic fundamentals are expected to explain, as previously stated. Therefore, underlying this definition is the need to accurately account for fundamentals. For that reason, a dynamic panel specification is adopted to account for country-specific effects and to mitigate any potential auto-correlation stemming from the persistence of sovereign yields. The following probit regression is analyzed:

$$Pr[y_{i,t} = 1|X_{i,t}, P_t, y_{i,t-1}, D_t, \beta, \gamma, \delta, \eta] = F[X_{i,t}^{'}\beta + P_t^{'}\gamma + y_{i,t-1}^{'}\delta + D_t^{'}\eta + \varepsilon_{i,t}] \tag{3.1}$$

$$\varepsilon_{i,t} = \alpha_i + u_{i,t}$$

where subindexes i and t refer to country and time. $y_{i,t}$ corresponds to the previously stipulated

financial stress indicator, whereas $y_{i,t-1}$ refers to the lagged dependent variable, whose coefficient allows for the study of positive state dependence of financial distress (Heckman, 1981), that is, whether or not previous periods of financial stress affect countries in a persistent manner.

Regressors were chosen to assess the response of financial distress to both common determinants (*push* factors, represented in vector P_t) and determinants specific to the countries themselves (*pull* factors, through vector $X_{i,t}$), drawing on existing literature (see, *inter alia* Bernoth and Erdogan, 2010 and Comelli, 2012) even if it is the case that economists still debate on the appropriate set of variables to control for. This study includes additionally vector D_t, corresponding to a compilation of events that we *a priori* believe to be relevant in influencing the financial distress of Euro area members either positively or negatively during the period under analysis. Moreover, cluster-robust standard errors are used to control for serial correlation in $\varepsilon_{i,t}$. The idiosyncratic error term $u_{i,t}$ is assumed to be independent across both i and t.

The use of panel data requires assumptions to be made on unobserved effects α_i. Since country-specific effects are unlikely to be orthogonal to explanatory variables, a fixed-effects model should be used. However, fixed-effects on non-linear models such as probit generally suffer from the *incidental parameters problem* (Neyman and Scott, 1948), where estimates of β are inconsistent because there is only a fixed number of observations to estimate each unobserved effect α_i, leading this inconsistency to be propagated to all coefficients and their respective marginal effects due to the non-linearity of the model (Cruz-Gonzalez et al., 2017). For this purpose, this paper follows most of the literature assuming a random-effects specification as opposed to fixed-effects, given the importance of estimating marginal effects.

The choice of a random-effects approach to avoid the *incidental parameters problem* does not permit the mitigation of the another problem: the *initial conditions problem*, where the initial period $y_{i,0}$ is likely to be correlated to $\varepsilon_{i,t}$, which will in turn affect $y_{i,t}$. If this is ignored and $y_{i},_{0}$ is treated as exogenous, then inconsistent estimates will be obtained: if financial stress in day 1

is associated with financial stress occurring at day 0 because of both unobserved heterogeneity and state dependence, without correcting for the underlying bias, the coefficient on $y_{i,t-1}$ will be overestimated and the coefficients on the remaining regressors will likely be underestimated.

Arguably, the fact that this panel holds a very substantial T (4,806 time periods) poses a strong argument on the insignificance of both issues and using a simple dynamic probit with random-effects is likely to report similar results. Notwithstanding, a robustness check is performed by including a model correcting for this bias with the Wooldridge estimator (Wooldridge, 2005) to account for initial conditions in non-linear, dynamic probit models and thus verify whether reported coefficients differ substantially from those obtained originally.

3.3 Identifying Financial Contagion: Time Series Analysis

After identifying the baseline economic fundamentals, this paper tests for the presence of contagion across EMU countries in times of distress using a time series framework.

First, one should note that the use of a probit model implies that results on contagion should be interpreted as a statistically significant increase in the probability of financial distress of a given country conditional on another becoming distressed, in line with a sizable portion of the literature that evaluates contagion as the shift in co-movements occurring in extreme periods.

Having already corrected for the issue of collinearity amongst regressors by creating a binary stress indicator, the problem becomes another, stemming instead from the fact that a lot of the tranquil periods (*stress=0*) overlap. This means that the simple inclusion of all financial stress variables in the baseline regression simultaneously would lead to biased and inconsistent results (reported with a sign which is contrary to theory and previous research). In order to avoid this issue, this paper relies on the methodology proposed by Sala-i-Martin (1997) where the stress indicators of three other countries (j, l and m) are added to the initial regression in combinations of 3 out of the remaining 11 EMU countries for which data was collected. In total, each country $i=1,\ldots,N$ will require 165 probit regressions (C_3^{11}) plus 165 other regressions for the computation

of the marginal effects. That being said, variables $y_{j,t}$, $y_{l,t}$ and $y_{m,t}$ correspond to indicators that take value one whenever country j, l and m are experiencing financial stress, respectively.

$$\begin{aligned} Pr[y_{i,t} = 1 | X_{i,t}, P_{i,t}, y_{i,t-1}, D_t, \beta, \gamma, \delta, \eta, \theta_{j,t}, \theta_{l,t}, \theta_{m,t}] \\ = F[X_{i,t}^{'} \beta + P_{i,t}^{'} \gamma + y_{i,t-1}^{'} \delta + D_t^{'} \eta + y_{j,t}{}' \theta_{j,t} + y_{l,t}{}' \theta_{l,t} + y_{m,t}{}' \theta_{m,t} + \varepsilon_{i,t}] \end{aligned} \tag{3.2}$$

Sala-i-Martin developed this model to robustly define the determinants of economic growth after finding existing tests too restrictive. In a set of 58 possible explanatory variables, Sala-i-Martin randomly draws regressors in sets of three, running millions of regressions, weighing each one by its integrated likelihood and then studying the response of the dependent variable.

By using this methodology in this study, contagion is evaluated as the significance of a given country's stress indicator in justifying the stress of remaining countries, when controlling for *push* and *pull* factors in order to be able to disentangle contagion from interdependence. Furthermore, it is possible to report (i) the average impact of country *j*'s financial stress on country *i*, weighted by the integrated likelihood of each regression in which it was included and (ii) the fraction of these in which it was statistically significant. This ensures robustness of results obtained.

The inclusion of other countries' financial stress indicators as regressors in the model to identify contagion is not free of criticism. In fact, one country's financial stress is likely to influence another's, exacerbating its own and leading to a case of endogeneity via reverse causality. There's a certain circularity in stress which is somewhat self-explanatory within the context of a monetary union because yields are tightly linked. In order to mitigate this problem, this paper lags the financial stress of other countries by one day, as markets adjust fairly quickly.

4 Data[1]

4.1 Countries' Stress Indicators

For the construction of countries' stress indicators, data was collected regarding **the 10-year sovereign bond yields**[2] of 12 EMU countries (Portugal, Spain, Italy, France, Ireland, Belgium,

[1] All data was obtained from Bloomberg.

[2] Sovereign bond yields were chosen over CDS spreads because existing literature has since proven that there have been policy actions that have significantly affected the first but not the latter (Bilal and Singh, 2012), and therefore to focus on CDS spreads could mean forgoing potentially relevant periods of financial distress.

Austria, Netherlands, Greece, Finland, Slovakia and Slovenia), and analyzed as a differential vis-à-vis Germany. During the crisis, the yield on the German Bund hit record lows while other countries' soared, proving its status as a proxy for a risk-free rate in what concerns debt markets. The frequency of this data is daily and covers the period from 1 Jan 2002 to 31 Aug 2020.[3] High frequency data was chosen to account for persistent effects of sovereign yields (De Santis, 2012).

One should note that Slovakia and Slovenia did not join the Euro at the same time as other member-states here included (Slovenia joined in Jan 2007 whereas Slovakia joined in Jan 2009). As mentioned by Ódor and Povala (2016), the analysis of credit risk premium of these countries in the period prior to their entry in the EMU is complicated, because even with the application of the ERM2 band for two consecutive years, yields are distorted by exchange rate fluctuations of the Slovak koruna and Slovenian tolar against the euro. This could pose a limitation to the analysis of the full sample period, as these countries are likely to present an exaggerated number of financial stress episodes. To mitigate this problem, contagious links will only be assessed from 2008 onward, considering the results of Ehrmann et al. (2011) who argue that convergence of sovereign yields seems to be achieved not by the adoption of the common currency itself, but rather by its anticipation. Likewise, Hüfner and Koske (2008) showed that by 2008, the spread between Slovak and German yields was already comparable to that of other EMU countries.

4.2 Economic Fundamentals

The choice on the set of explanatory variables for the identification of economic fundamentals was conditional on the availability of data. As many other studies that use high-frequency data (e.g. Favero et al., 2010), it is not possible to use variables that grasp macroeconomic and fiscal fundamentals, only available at lower frequencies. Nonetheless, regressors chosen aim to reflect aggregate risk, global liquidity and stress in the interbank market (*push* factors) as well

[3]Exceptions are Slovakia and Slovenia, both due to data unavailability. The former only has data starting on 19 Jun 2002 and has a gap corresponding to the period between 1 Dec 2006 and 31 May 2007. The latter's data only starts on 4 Apr 2007. Furthermore, data for Luxembourg was not collected because it did not have a debt security with a maturity of ten years until mid-May 2010.

country-specific risk, following extensive literature on the determinants of sovereign yields (e.g. Afonso et al., 2012; Bernoth and Erdogan, 2010).

In what concerns *push* factors, vector P_t includes: (i) the **Chicago Board Options Exchange Market Volatility Index (VIX)**, often known as Wall Street's "fear gauge", in order to reflect the implied volatility of international financial risk perceptions of global markets, thus proxying for market risk aversion; (ii) **Interbank Tensions**, through the spread between the three-month Euribor and the three-month overnight index swap (OIS) rates, well-cited to be a barometer of distress in the banking system (Đukić and Đukić, 2011); (iii) the **U.S. 10-Year Treasury Note Yield**, historically perceived as riskless and benefiting from a certain safe-haven status, included as a measure of global liquidity and to assess the existence of flight-to-safety (where stress in one country induces the opposite reaction in U.S. yield); (iv) the **EUR-USD Exchange Rate**, to reflect fundamentals in the Euro area, as an increase in its value entails a weakness of the currency (depreciation), consistent with a higher variation in yields and thus, financial stress.

Vector $X_{i,t}$ (*pull* factors) includes: (i) the launch of the **Excessive Deficit Procedure** for countries' lack of compliance with EMU's thresholds; and (ii) **Sovereign Credit Rating**, measured by the average credit rating attributed by the three main Rating Agencies (Moody's, Fitch and Standard & Poor's) after being codified the into a linear numerical scale as in Afonso et al. (2012)'s empirical research (Table A.3 on the Appendix). Its inclusion follows several authors who document significant responses of yields to changes in credit ratings, indicating that these are able to spur financial instability (e.g. Arezki et al., 2011 and De Santis, 2012).

Before proceeding to estimation results, it is necessary to address some concerns that question the validity of the model, namely, the presence of endogeneity. One can expect that a given country's credit rating changes as a response to financial stress the same way one expects the yield spread to widen as a response to a rating downgrade. The fact that sovereign rating can implicate and be implicated by financial stress, originates a negative bias. However, using daily

data provides a way to mitigate contemporaneous endogeneity as it is unlikely that ratings change at the same time as yields and vice-versa. In fact, it can even be argued that, as rating agencies often aim to promote stability, they only change a given rating when they are certain that any change in the country's risk profile is likely to be permanent, leading credit ratings to lag yield spreads and this paper to conclude that the presence of endogeneity is unlikely. In a pivotal work, Hull et al. (2012) find evidence that yield spreads often anticipate credit rating reviews, in particular for downgrades. This seems to suggest not only the relative importance of rating downgrades over upgrades but also the need to lag this regressor by one day in order to better reflect direct causality. For this reason, instead of average rating, a lagged indicator variable for credit rating downgrades is included. Nonetheless, as a robustness check, an additional model is computed where the lagged downgrade is instrumented by a three-day lag, following Hull et al. (2012)'s findings that spreads adjust fully to the information in the rating change by day +1. While this might not offer the best possible instrumentation, it does allow for the computation of a Wald test to assess this paper's hypothesis of exogeneity.

It is also necessary to assess the possibility of non-stationarity of the model's regressors. For this purpose, unit-root tests are conducted on each variable. The vast majority of those included are integrated of order zero and thus pose no problem (see Table A.4 on the Appendix). However, interbank tensions and U.S. yield are integrated of order one, so, in order to correct for this issue, the change in these variables is used instead of the variables in levels, such that:

$$\Delta IT_{i,t} = IT_{i,t} - IT_{i,t-1}$$

$$\Delta US_{i,t} = US_{i,t} - US_{i,t-1}$$

Finally, vector D_t represents a set of 8 dummy variables corresponding to specific events that may have influenced country stress. It includes: (i) the news, on 21 Oct 2009 that the Greek deficit for the year of 2008 surpassed 12% of GDP; (ii) the lowering of ECB's quality requirements for **eligibility of debt to be used as a collateral from an A- to a BBB- rating**

on 25 Mar 2010; (iii) the announcements of the European Financial Stability Facility (EFSF) and that, within the **Security Markets Programme (SMP)** the ECB and other central banks of the Euro area would start purchasing securities, on 10 May 2010; (iv) the announcement of two **Long-Term Refinancing Operations (LTROs)**, on 8 Dec 2011; (v) Mario Draghi's declaration that the ECB would do **"whatever it takes"** to save the Euro, on 26 Jul 2012; (vi) the announcement of the **Quantitative Easing Programme** on 22 Jan 2015; (vii) the announcement (or the lack of thereof) of measures to help counter the COVID-19 crisis, on **12 Mar 2020**, a day of great expectation that the ECB would cut its benchmark rate (incidentally coinciding as well with the announcement by President Trump that the U.S. would suspend the entry of Europeans in American territory because of the vast increase in the number of infections); and finally (viii) the announcement on 18 Mar 2020 of the **Pandemic Emergency Purchase Programme (PEPP)**, where €750 Billion would be provided to help counter the COVID-19 crisis.

5 Empirical Analysis

5.1 Periods of Financial Stress

Table 5.1: Episodes of Financial Stress[4,5]

Country	Ep.	Pctg.	Country	Ep.	Pctg.	Country	Ep.	Pctg.
Austria	57	17.9%	Greece	80	19.7%	Portugal	69	19.5%
Belgium	56	19.5%	Ireland	60	18.8%	Slovakia	137	23.4%
Finland	51	17.3%	Italy	55	17.3%	Slovenia	88	19.2%
France	71	20.4%	Netherlands	55	17.6%	Spain	61	18.3%

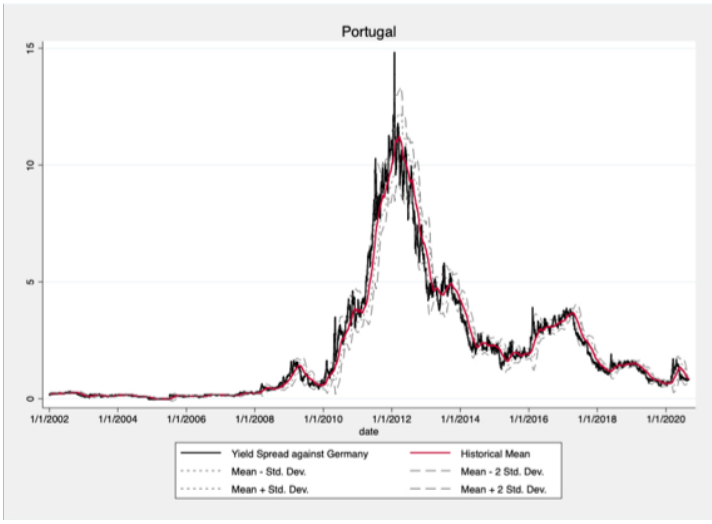
Table 5.1 summarizes the number of episodes of financial stress and the corresponding percentage of time out of the full period that was spent under stress for all sampled countries (Panel B of Table A.1 on the Appendix offers additional statistics). Surprisingly, the fraction of time spent under stress is somewhat homogeneous across countries, contradicting the common notion that periphery countries are more volatile and thus more prone to financial stress. In fact, similar values are found between Finland and Italy or Greece, Belgium and France, for instance.[6]

[4]Unless stated otherwise, all tables and figures in this paper are based on own calculations.

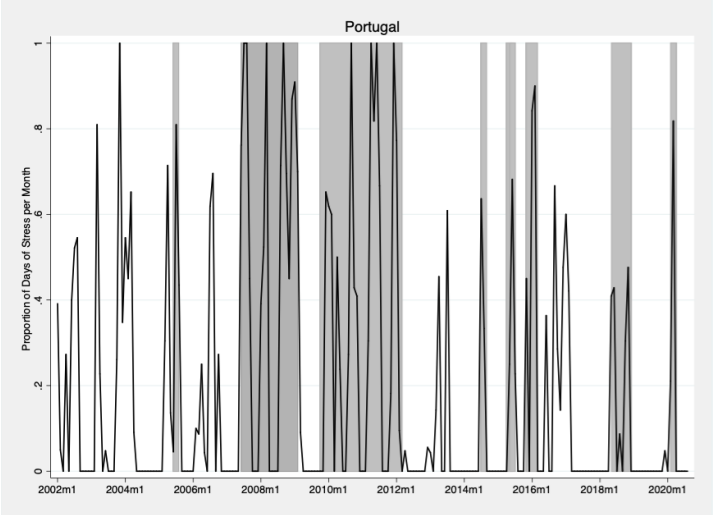
[5]As previously explained, the considerable number of stress episodes presented by Slovakia and Slovenia may be related with these countries' late entry into the common currency.

[6]In line with these results, Basse (2013) finds that bond markets seemingly have stopped accepting France as belonging to the EMU's core group.

Figure 5.1: Financial Stress in Portugal 2002-2020



(a) Overview of Stress periods in Portugal



(b) Proportion of Days of Stress per Month in Portugal

Taking Portugal as an example for further analysis, 69 stress episodes were found (totaling 939 days), of which 10 (corresponding to 230 days) occur during the sovereign debt crisis. Panels *a* and *b* of Figure 5.1 present a graphical representation of these periods for the case of Portugal.[7]

A qualitative assessment of the Portuguese stress indicator was performed using historical news records from *Financial Times*, *Reuters* and *Jornal de Negócios*.[8] Despite the existence of a certain degree of subjectivity associated to media sources, by complementing an empirical analysis with a narrative approach, this study is able to counter some of the ambiguity surrounding these events. Particularly, panel *b* highlights that this stress indicator seems to fit well with the narrative of key facts and episodes occurring in the Portuguese economy. For instance, it is possible to infer that the shaded area referring to Jun - Jul 2005 concerns Standard & Poor's downgrade of Portugal's credit rating to AA –. The two largest areas refer to several shocks under the subprime crisis (Jun 2007 - Feb 2009) and the Eurozone sovereign debt crisis (Oct 2009 - Feb 2012), respectively. Mid 2014, yields reached the year's high due to the rescue of Banco Espírito Santo, and again at the end of 2015 on fears that the new anti-austerity government

[7] Those of other countries are included in the Appendix, Figures A.1 to A.12.

[8] Table A.2 on the Appendix presents a detailed study of the 69 stress episodes found for Portugal.

would be unstable policy-wise. Fears in 2016 refer to the aftermath of the Brexit referendum and in May - Oct 2018 as a response to the uncertainty in Italian politics after a hung parliament. Finally, the spike in Mar 2020 refers to the lockdown caused by the COVID-19 pandemic.

This analysis suggests that Portugal is vulnerable to the international environment, as yields surge in response to pressures on its creditworthiness from rating agencies and unrelated crises in countries like the U.K. or Italy. These results seem to reinforce the idea of a certain interdependence between EMU countries, which is to be expected in a monetary union, but also that a large number of distress periods occurring after the end of the sovereign debt crisis arise in tandem of other countries' political crises. This suggests evidence on "wake-up call" contagion in the Eurozone, as this crisis may have functioned as the "unfavorable signal" trigger that made markets reassess their views on certain countries, which further motivates this research.

5.2 Assessing Economic Fundamentals: Panel Analysis

Table 5.2 reports the estimates on the initial regression for the identification of economic fundamentals. Columns 1 to 3 present the results using a simple dynamic probit with random-effects approach (Column 1), a dynamic probit with random-effects correcting for the initial conditions problem (Column 2) and a dynamic probit using a two-stage-least-squares IV approach in order to account for potential endogeneity stemming from lagged downgrade, where a 3-day lag is used as instrument (Column 3). The first two columns show very similar results, sustaining the hypothesis that the time-span covered by the model is sufficiently large to avoid the typical limited dependent variable model problems. As expected, the result on the Wald test of exogeneity does not suggest that lagged downgrade is endogenous. Therefore, this paper focuses solely on the first model (marginal effects - column 4 - are only computed for this model).

Baseline results point to periods of financial stress being seemingly sensitive to the common culprits studied in the literature. Global risk aversion (VIX) and interbank tensions ($\Delta\ IT_{i,t}$) increase the probability of financial stress. The negative sign on the coefficient for U.S. yield

seems to imply some evidence on flight-to-safety to the U.S. in times of crisis. These are results consistent with previous studies on determinants of sovereign bond spreads (Afonso et al., 2012). We find that the probability of stress after the implementation of LTROs or PEPP is lower by 1.2 and 27.9 percentage points, respectively, when compared to the absence of measures, *ceteris paribus*. This contrasts with the 1.7 and 23.6 percentage point increase in the probability of stress after the Greek deficit reveal and the events of Mar 12, respectively.

Table 5.2: Determinants of Financial Stress (Panel Analysis)

	Simple	Bias-Corrected	IV	Marginal Effects
	Stress	Stress	Stress	Stress
Lagged Stress	3.516***	3.516***	3.553***	0.209***
	(0.0787)	(0.0787)	(0.0427)	(0.009)
$X_{i,t}$				
EDP	0.0432	0.0424	0.065*	0.003
	(0.0299)	(0.0299)	(0.0367)	(0.009)
Lagged Downgrade	−0.0277	−0.0249	−11.054	−0.002
	(0.154)	(0.154)	(10.269)	(0.002)
D_t				
Greek Deficit Reveal	0.282***	0.282***	0.296***	0.017***
	(0.0925)	(0.0922)	(0.0891)	(0.005)
A+ to BBB−	−0.311***	−0.310***	−0.264***	−0.018***
	(0.0790)	(0.0788)	(0.0793)	(0.004)
SMP	0.0401	0.0401	0.0479	0.002
	(0.0582)	(0.0581)	(0.0724)	(0.004)
LTROS	−0.205***	−0.208***	−0.120	−0.012***
	(0.0789)	(0.0799)	(0.1071)	(0.004)
"*Whatever It Takes*"	−0.110	−0.108	−0.246*	−0.007
	(0.124)	(0.123)	(0.149)	(0.007)
QE	0.178*	0.176*	0.249**	0.011*
	(0.0913)	(0.0914)	(0.113)	(0.005)
March 12^{th}	3.957***	3.992***	3.576	0.236***
	(0.0913)	(0.0914)	(147.99)	(0.018)
PEPP	−4.679***	−4.715***	−4.279	−0.279***
	(0.135)	(0.139)	(147.99)	(0.016)
P_t				
VIX	0.0166***	0.0166***	0.0163***	0.001***
	(0.00124)	(0.00124)	(0.00169)	(0.0001)
EUR/USD	0.493***	0.493***	0.494***	0.029***
	(0.106)	(0.106)	(0.108)	(0.005)
ΔIT	2.729***	2.729***	2.804***	0.162***
	(0.471)	(0.471)	(0.639)	(0.033)
ΔUS	−1.991***	−1.991***	−1.958***	−0.118***
	(0.129)	(0.129)	(0.197)	(0.009)
Observations	54,606	54,606	54,606	54,606
Wald Test	-	-	1.2	-

Robust standard errors in parentheses
*** p < 0.01, ** p < 0.05, * p < 0.1

We find no statistical significance on the coefficients associated with credit rating, SMP and the "whatever it takes" speech. This is a particularly surprising as the latter is often cited as one

of the main factors for the decrease of tensions in the euro bond market as a whole. One may argue that, while the speech did in fact substantially reduce yields in the periphery, it also led to an increase in yields of countries like the Netherlands or Finland, as the purchases by core countries' investors of periphery debt is likely to increase yields on core countries. Therefore, this result is likely reflecting a re-balancing of portfolios in terms of sovereign debt, where the average Euro area yield had already been decreasing by the time the speech took place.

Finally, the coefficient on the lagged dependent variable is statistically significant (having experienced financial stress in previous periods increases the likelihood of stress in the current period by 20.9 percentage points), which implies the presence of "true state dependence".[9]

5.3 Evidence of Financial Contagion: 2002-2020

Table 5.3: Determinants of Portuguese Stress including other Countries' Stress Indicators

	Times Included	Average Coefficient	Average Mg. Effect	Average Std. Error	Times Significant
Lagged Stress D_t	165	3.428	0.207	0.087	100%
Greek Deficit Reveal	165	0.217	0.013	0.247	0%
$A+$ *to* $BBB-$	165	−0.105	−0.006	0.255	0%
LTROS	165	−0.263	−0.016	0.129	72%
Mar 12^{th}	165	3.153	0.191	0.364	100%
PEPP P_t	165	−4.238	−0.257	0.504	100%
VIX	165	0.008	0.0005	0.005	0%
EUR/USD	165	−0.295	−0.178	0.317	0%
ΔIT	165	3.702	0.224	2.113	0%
ΔUS $Stress_{t-1}$	165	−1.450	−0.088	0.637	100%
Austria	45	−0.152	−0.009	0.130	0%
Belgium	45	0.217	0.013	0.115	44%
Finland	45	0.150	0.091	0.109	9%
France	45	0.024	0.001	0.107	0%
Greece	45	0.388	0.023	0.106	100%
Ireland	45	0.168	0.010	0.113	18%
Italy	45	0.287	0.017	0.114	87%
Netherlands	45	0.170	0.010	0.108	11%
Slovakia	45	0.070	0.004	0.099	0%
Slovenia	45	0.085	0.005	0.107	0%
Spain	45	0.055	0.003	0.111	0%

Table 5.3 displays the estimates for the model aimed at identifying financial contagion,

[9] Before proceeding with the estimation of contagion coefficients in a time series framework, all variables that hold no statistical power in the baseline regression are removed to move on to a more country-specific analysis.

specifically for the case of Portugal during the entire sample period. Column 1, 2 and 3 report the average coefficient, marginal effect and standard errors of each variable as weighted by the integrated-likelihood of each one of the models, respectively. Most importantly, column 5 presents the fraction of times each variable was statistically significant at a 5% level in explaining Portuguese stress. In his paper, Sala-i-Martin settles the statistical significance of a variable when the fraction of times it was significant at 5% is over 95%. Without any loss of information, a more comprehensive classification is considered in this paper, as a variable that is significant 80% of the times is likely to have sufficient statistical power for inference to be made.

A first important finding relates to the fact that variable VIX, representative of global risk factors, now loses its statistical significance once the model accounts for other countries' stress.

Table 5.4: Significance of Country Stress Indicators & VIX in explaining a Country's Stress

		Influencee												
		AUS	**BEL**	**FIN**	**FRA**	**GRE**	**IRE**	**ITA**	**NEL**	**POR**	**SLK**	**SLV**	**SPA**	**VIX**
Influencer	**AUS**	-	0%	0%	69%	0%	0%	7%	64%	0%	0%	0%	0%	100%
	BEL	100%	-	0%	100%	29%	73%	100%	87%	42%	11%	84%	100%	100%
	FIN	7%	24%	-	7%	0%	7%	0%	27%	7%	16%	0%	0%	100%
	FRA	44%	0%	0%	-	0%	0%	16%	0%	0%	84%	0%	62%	69%
	GRE	0%	100%	0%	0%	-	0%	100%	0%	100%	0%	13%	11%	100%
	IRE	38%	73%	0%	51%	31%	-	40%	78%	40%	0%	40%	27%	100%
	ITA	10%	100%	4%	100%	89%	100%	-	87%	91%	100%	100%	100%	69%
	NEL	53%	0%	0%	7%	0%	0%	0%	-	2%	84%	0%	0%	98%
	POR	27%	57%	0%	16%	100%	80%	7%	0%	-	9%	42%	51%	100%
	SLK	69%	0%	0%	0%	0%	0%	0%	0%	0%	-	100%	0%	100%
	SLV	0%	0%	0%	0%	0%	0%	0%	0%	0%	100%	-	0%	100%
	SPA	98%	76%	0%	60%	0%	62%	80%	98%	0%	7%	0%	-	100%
	VIX	26%	0%	15%	0%	61%	72%	0%	0%	27%	100%	100%	0%	-

For a more general view, Table 5.4 reports, in matrix form, the percentage of times each country and VIX were statistically significant at 5% in explaining each country's periods of stress. The rows correspond to the "contagious" country and the columns to the country whose stress is being influenced. The loss of significance of VIX seems to be widespread across several countries apart from Slovakia and Slovenia (last row on Table 5.4).[10] This points towards evidence that contagious links are likely being captured by global risk factors when not directly

[10]Results for the model including Slovakia and Slovenia must be interpreted with caution, as their stress variables could be highly influenced by exchange rate volatility prior to their entry in the Euro, as previously stated.

accounted for, suggesting that the significance found in a panel data setting occurred merely due to biased estimates as a result of omitted variables. Nonetheless, as pointed out by Caceres et al. (2010), failing to separate global from country-specific shocks will lead to misspecification errors, as when a common shock forces two countries to move in tandem (Forbes and Rigobon, 2002). This is often the case with changes in interest rates or oil prices, for example. In order to ensure that this study is robust to such errors, we proceed to a careful examination of the role of VIX in country regressions in order to assess the dimension of the problem.

Table 5.5: Determinants of Portuguese Stress with and without VIX & Country Stress Indicators

	Including Everything		Excluding VIX			Excluding Stress		
	Avg. Coef.	Avg. M.E.	Avg. Coef.	Avg. M.E.		Avg. Coef.	Avg. M.E.	
	Stress	Stress	Stress	Stress	z-stat	Stress	Stress	z-stat
Austria	−0.152	−0.009	−0.112	−0.007	−0.226	-	-	-
Belgium	0.217	0.013	0.299	0.012	0.114	-	-	-
Finland	0.150	0.091	0.166	0.010	−0.108	-	-	-
France	0.024	0.001	0.038	0.002	−0.094	-	-	-
Greece	0.388	0.023	0.408	0.025	−0.136	-	-	-
Ireland	0.168	0.010	0.198	0.012	−0.198	-	-	-
Italy	0.287	0.017	0.274	0.017	0.081	-	-	-
Netherlands	0.170	0.010	0.240	0.013	−0.222	-	-	-
Portugal	-	-	-	-	-	-	-	-
Slovakia	0.070	0.004	0.082	0.005	−0.086	-	-	-
Slovenia	0.085	0.005	0.165	0.010	−0.555	-	-	-
Spain	0.055	0.003	0.081	0.005	−0.162	-	-	-
VIX	0.008	0.0005	-	-	-	0.011	0.0007	−0.454
Lagged Stress	3.428	0.207	3.430	0.210	−0.018	3.510	0.215	-
Greek Deficit Reveal	0.217	0.013	0.185	0.011	0.094	0.191	0.011	-
A+ to BBB−	−0.105	−0.006	−0.098	−0.011	−0.021	−0.041	−0.003	-
LTROS	−0.263	−0.016	−0.260	−0.016	−0.021	−0.279	−0.017	-
Mar 12^{th}	3.153	0.191	3.610	0.221	−1.101	3.275	0.201	-
PEPP	−4.238	−0.257	−4.273	−0.246	0.308	−4.339	−0.266	-
EUR/USD	−0.295	−0.178	−0.156	−0.010	−0.313	−0.170	−0.010	-
ΔIT	3.702	0.224	3.533	0.216	0.058	3.646	0.223	-
ΔUS	−1.450	−0.088	−1.608	−0.098	0.175	−1.446	−0.089	-
R^2	0.228	-	-	-	-	-	-	-
$Adj.\ R^2$	0.226	-	-	-	-	-	-	-

[1]Avg. Coef. and Avg. M.E. refer to the Average Coefficient and Average Marginal Effect.
[2]Columns 1 and 2 correspond to the average coefficients and marginal effects of a model including both VIX and countries' stress indicators, columns 3 and 4 exclude VIX while columns 6 and 7 exclude the countries' stress indicators.
[3]z-stat on columns 5 and 8 refer to the result of a z-test for the equality of coefficients, where the alternative hypothesis is that coefficients are statistically different. Column 5 tests whether stress coefficients differ once variable VIX is removed, whereas column 8 tests whether the coefficient on VIX differs once stress indicators are removed.

Several things are worth stressing. First, as per the last column on Table 5.4, the stress of other

countries seems to be a statistically significant determinant of VIX. However, the R^2 obtained from regressing VIX on all country stress indicators simultaneously is only about 23%, hinting that there is more in VIX than Euro-denominated stress. This attests that results are not merely due to global shocks that increase co-movements between countries because of interdependence alone. Table 5.5 analyses the relevance of differences between models including VIX and country stress indicators in alternate when estimating the determinants of Portuguese stress. Columns 1 and 2 report the average coefficients and marginal effects of a model including both VIX and countries' stress indicators (the same as reported on Table 5.3), columns 3 and 4 exclude variable VIX, while columns 6 and 7 exclude the stress indicators. By testing the differences between these three models, we are able to assess the volatility of variable VIX. Z-tests are conducted to test for the equality of coefficients (columns 5 and 8). It follows that the inclusion of VIX does not seem to greatly disturb the stress coefficients, nor is the coefficient on VIX seemingly affected by the inclusion of stress variables, given that results on z-tests are insignificant.

This analysis suggests that contagion tends to be statistically manifested by global risk factors when not directly accounted for. That being true, VIX's influence under a panel data specification is spurious due to omitted variable bias, which is, to the best of our knowledge, a novel result.

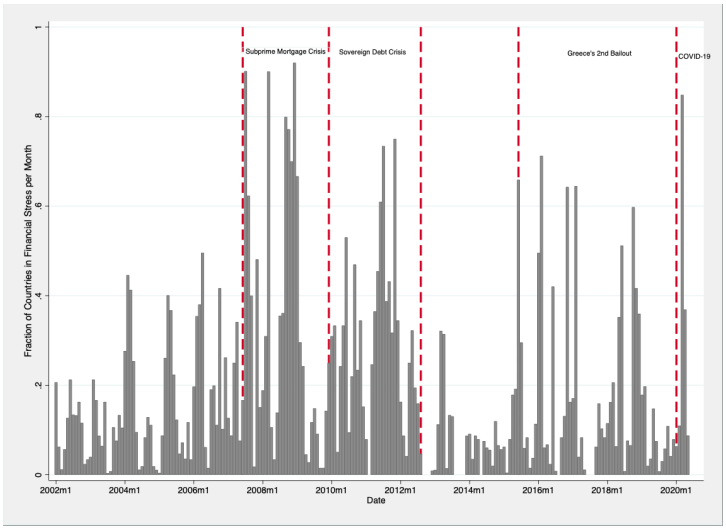
5.4 Evidence of Financial Contagion: Subperiods

Moving forward to the analysis of the presence of contagion itself, it would seem that, perhaps more relevant than analysing the full period from 2002 to 2020, would be to analyse specific subperiods. A total of 5 relevant events were considered. The selection of these events was made by plotting the average number of countries under stress per month and searching for structural breaks separating roughly homogeneous periods, as highlighted in Figure 5.2[11]: (i) the onset of the subprime mortgage crisis (Jun 2007); (ii) Greece's first downgrade (by Fitch) following the reveal of a 12.5% deficit, on 8 Dec 2009; (iii) Mario Draghi's "whatever it takes" speech on 26

[11] Unfortunately, this is not entirely possible, as the computation of a regression of this size requires that all countries have stress episodes in every period to be able to play a role in each other's stress. For this reason, some periods have to be larger and not unconditionally similar in terms of the number of countries under financial stress.

Jul 2012[12], (iv) when it became apparent that Greece is set to default on its debt repayment loans to the IMF and will likely need another bailout (May 2015); and (v) the COVID-19 pandemic.

Figure 5.2: Fraction of Countries experiencing Financial Stress per month



Some limitations should be accounted for when using a probit model, namely, the failure to analyse periods with few stress episodes. This does not allow for the comparison between tranquil and crisis periods (as in Forbes and Rigobon, 2002 to better distinguish between contagion and interdependence). However, even if one can never claim results constitute unambiguous proof of contagion, analysing solely extreme occurrences of sovereign yields as well as controlling for *push* factors as proxies for global shocks does offer some reassurance, since results will reflect a financial linkage between countries beyond what ordinary conditions can explain.

On the basis of this limitation, the time span between the "whatever it takes" speech and Greece's 3rd bailout, as well as the COVID-19 crisis are not susceptible of analysis. Furthermore, a valid assessment of contagious links can only consider Slovakia and Slovenia's financial stress from 2008 onward, as previously mentioned. As such, Table 5.6 presents the fraction of times other countries were statistically significant in explaining a given country's stress, where Panel A presents the results for the period between Greece's Fitch downgrade and the "whatever it takes"

[12]While this may seem a contradictory result when compared to the statistical insignificance obtained under a panel specification, by July 2012 only about 2 countries were experiencing financial stress. While the speech effectively marks the end of the sovereign crisis, its impact wasn't as vital in perspective.

speech, and Panel B the period between Greece's 3rd bailout and 31 Dec 2019.

Table 5.6: Significance of other Countries' Stress Indicators in explaining a Country's Stress

Panel A: From Greece's first downgrade following the reveal of a 12.5% deficit (8 Dec 2009) to Mario Draghi's "whatever it takes" speech (26 Jul 2012)[13]

		Influencee											
		AUS	**BEL**	**FIN**	**FRA**	**GRE**	**IRE**	**ITA**	**NEL**	**POR**	**SLK**	**SLV**	**SPA**
Influencer	**AUS**	-	100%	0%	56%	0%	20%	0%	0%	0%	13%	0%	0%
	BEL	0%	-	0%	91%	16%	2%	0%	36%	0%	0%	0%	0%
	FIN	0%	78%	-	0%	0%	31%	0%	0%	0%	0%	0%	0%
	FRA	0%	69%	0%	-	100%	0%	0%	0%	35%	0%	0%	31%
	GRE	0%	0%	0%	31%	-	0%	0%	0%	83%	2%	0%	0%
	IRE	0%	13%	0%	56%	20%	-	0%	0%	100%	53%	0%	0%
	ITA	39%	24%	0%	91%	0%	100%	-	4%	22%	96%	73%	0%
	NEL	0%	11%	0%	0%	0%	0%	7%	-	0%	0%	0%	0%
	POR	0%	0%	0%	0%	29%	0%	0%	0%	-	67%	0%	7%
	SLK	0%	0%	0%	47%	0%	0%	0%	0%	0%	-	0%	0%
	SLV	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	-	0%
	SPA	57%	40%	0%	62%	7%	0%	100%	73%	9%	22%	0%	-

Panel B: From Greece's 3rd bailout (22 May 2015) to 31 Dec 2019[14]

		Influencee											
		AUS	**BEL**	**FIN**	**FRA**	**GRE**	**IRE**	**ITA**	**NEL**	**POR**	**SLK**	**SLV**	**SPA**
Influencer	**AUS**	-	31%	0%	7%	0%	7%	0%	65%	0%	0%	0%	0%
	BEL	100%	-	0%	100%	9%	0%	36%	58%	38%	4%	93%	93%
	FIN	0%	93%	-	2%	0%	0%	0%	0%	0%	0%	0%	0%
	FRA	0%	11%	0%	-	0%	0%	0%	2%	0%	4%	0%	51%
	GRE	0%	0%	0%	0%	-	0%	0%	0%	100%	0%	57%	0%
	IRE	22%	100%	0%	80%	0%	-	31%	89%	100%	0%	0%	29%
	ITA	62%	91%	22%	100%	0%	100%	-	84%	7%	100%	100%	100%
	NEL	0%	0%	0%	0%	0%	0%	0%	-	0%	58%	0%	9%
	POR	0%	53%	0%	0%	100%	0%	22%	0%	-	0%	33%	0%
	SLK	0%	0%	0%	0%	0%	0%	0%	0%	0%	-	0%	0%
	SLV	56%	0%	0%	16%	0%	0%	0%	0%	22%	0%	-	0%
	SPA	24%	2%	2%	9%	0%	0%	100%	16%	0%	0%	0%	-

The first, most intuitive result one can derive is that, contrary to popular belief, Greece does not seem to be as "contagious" as the literature describes it. In fact, it only seems to be a statistically significant determinant of Portuguese stress in both periods. This result is consistent with works such as Missio and Watzka (2011) and Conefrey and Cronin (2015), who find that Greece's impact on other markets subsided after mid-2010 and early 2012 as other countries saw Greek public finances as detached from their own. This may as well be due to ECB's prompt responses through the implementation of policies like its LTROs or the increase of its purchases through

[13]Number of episodes of stress during this period: Austria 14 (166 days), Belgium 17 (178 days), Finland 11 (133 days), France 15 (169), Greece 11 (260 days), Ireland 11 (256 days), Italy 16 (187 days), Netherlands 13 (123 days), Portugal 10 (230 days), Slovakia 13 (204 days), Slovenia 20 (313 days), Spain 14 (249 days).

[14]Number of episodes of stress during this period: Austria 9 (175 days), Belgium 13 (231 days), Finland 15 (219 days), France 17 (217 days), Greece 21 (107 days), Ireland 17 (215 days), Italy 17 (241 days), Netherlands 14 (202 days), Portugal 15 (166 days), Slovakia 12 (246 days), Slovenia 15 (203 days), Spain 18 (136 days).

the quantitative easing program, assuaging the general economic sentiment.

Perhaps our most important finding is the fact that causalities here implied are often not exclusive nor mutual, making it hard to group the countries with mutual relevance, especially during the sovereign debt crisis. While it seems that Belgium and France play a role in each other's stress, the same cannot be said for Austria, whose stress influences Belgium but the reverse is not true. Finland, for instance, seems to be somewhat detached from the euro-bond market sentiment, even if it plays a role in Belgian stress. Analogously, Irish and Greek stresses are not influenced by Portugal while the reverse holds. This debunks, to some extent, the common belief of a dichotomy between core and periphery countries.

This concept seems even more ambivalent and harder to apply following Greece's 3rd bailout, as some countries' stress seems to be transversal to the idea of groups. Italy more than doubles the number of countries it influences from one crisis period to another. Its discernible political crises in this period (mostly due to a hung parliament, which resulted in a long period of political instability), were able to affect the economic sentiment of several other Eurozone members, such as Belgium, France, Ireland, the Netherlands, Slovakia, Slovenia and Spain. This is a result that seems to offer some statistical strength to the hypothesis of "wake-up call" contagion, where financial markets report increased sensitivity between them, after an event forces them to reassess their views on other countries. This is corroborated to some extent by the seeming consistency of the vast majority of other contagious links when moving from one period to another.

6 Conclusion

Overall, this paper offers strong evidence on the presence of contagion within the sovereign bond market during periods of financial distress for certain Eurozone countries.

Main results can be summarized as follows. Using a dynamic panel, we find evidence on the sensitivity of periods of financial stress to the common culprits studied in the literature, such as global risk aversion, market iliquidity and currency volatility. Additionally, stress is found

to decrease in response to key ECB responses to crisis periods, such as the implementation of the LTROs or PEPP. A negative, statistically significant coefficient on U.S.' yield seems to provide evidence of flight-to-safety to the U.S. in times of distress. Contrary to popular belief, the well-known "whatever it takes" speech by Mario Draghi is not statistically significant, nor is the implementation of the SMP, when the stress of the Euro area as a whole is estimated. Evidence is additionally found on state dependence of financial stress, highlighting its persistence.

Under a time series setting for a country-specific analysis, we use the methodology proposed by Sala-i-Martin (1997) to account for other countries' stress indicators. The coefficients associated with variable VIX are no longer statistically significant, which seems to suggests that its influence under a panel data specification was likely due to an omitted variable bias. By controlling for *push* factors and restricting the analysis to abnormally high yield occurrences, there is some confidence that outcomes are able to reflect financial contagion as opposed to sole interdependence between countries. Results seemingly dispute the usual association of core and periphery countries, well-documented across the literature, as causalities found are nor exclusive nor mutual. Surprisingly, Greece's influence is not as extensive as previously thought. Italy's, however, is widespread over multiple countries, especially in the aftermath of the sovereign debt crisis, which seems to denote the presence of "wake-up call" contagion regarding this country's periods of tension.

As a final remark, while one must recognize the merits of a probit model for pinpointing extreme events, this is also a method that comes with limitations, namely that short-length crises cannot be analysed. Extending and improving this methodology for an application to more periods and more countries may be a good option for further research. As more data becomes available, for instance on the COVID-19 crisis, it would perhaps be interesting to evaluate the importance of financial contagion for different groups and compare the impact of different crises.

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Appendix

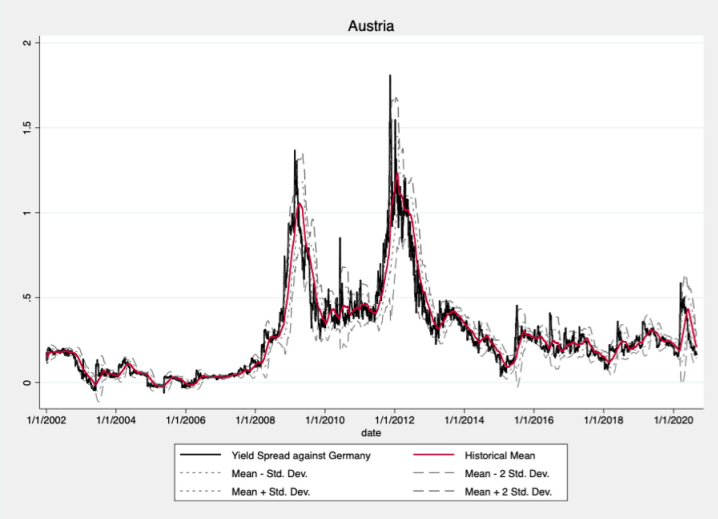
Table A.1: Descriptive Statistics and Correlations for Yields and Stress Variables

Panel A: Correlations of Yields

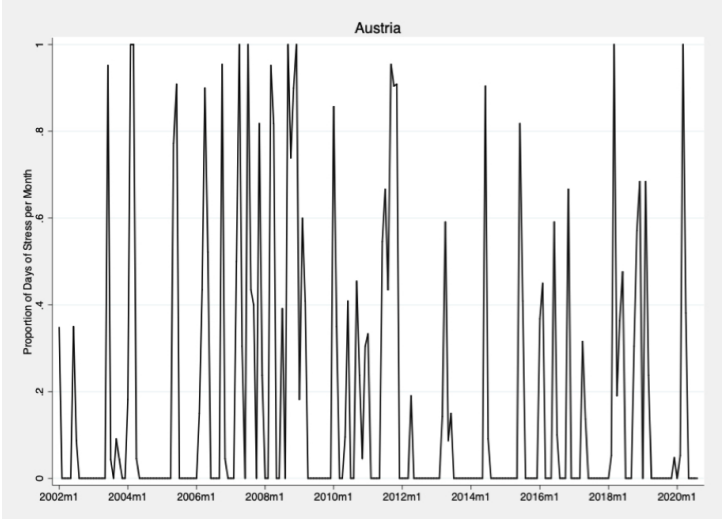
	AUS	BEL	FIN	FRA	GRE	IRE	ITA	NEL	POR	SLK	SLV	SPA
AUS	1.000											
BEL	0.998	1.000										
FIN	0.067	0.078	1.000									
FRA	0.997	0.989	0.064	1.000								
GRE	−0.022	0.108	−0.017	−0.002	1.000							
IRE	0.715	0.801	0.066	0.718	0.536	1.000						
ITA	0.819	0.883	0.073	0.832	0.425	0.872	1.000					
NEL	0.996	0.976	0.067	0.995	−0.082	0.676	0.787	1.000				
POR	0.421	0.542	0.027	0.443	0.841	0.847	0.777	0.371	1.000			
SLK	0.978	0.979	0.002	0.977	0.122	0.763	0.842	0.966	0.510	1.000		
SLV	0.819	0.863	0.053	0.842	0.545	0.800	0.915	0.803	0.790	0.859	1.000	
SPA	0.803	0.867	0.047	0.820	0.477	0.901	0.955	0.777	0.815	0.823	0.947	1.000

Panel B: Descriptive Statistics on Financial Stress

	No. Days	No. Periods	Mean	Std. Dev.	Min.	Max.
Stress: Austria	860	57	0.1789	0.3833	0	1
Stress: Belgium	938	56	0.1952	0.3964	0	1
Stress: Finland	832	51	0.1731	0.3784	0	1
Stress: France	978	71	0.2035	0.4026	0	1
Stress: Greece	945	80	0.1966	0.3975	0	1
Stress: Ireland	901	60	0.1875	0.3903	0	1
Stress: Italy	830	55	0.1727	0.3780	0	1
Stress: Netherlands	848	55	0.1764	0.3812	0	1
Stress: Portugal	939	69	0.1954	0.3965	0	1
Stress: Slovakia	1,126	137	0.2343	0.4236	0	1
Stress: Slovenia	924	88	0.1923	0.3941	0	1
Stress: Spain	880	61	0.1831	0.3868	0	1

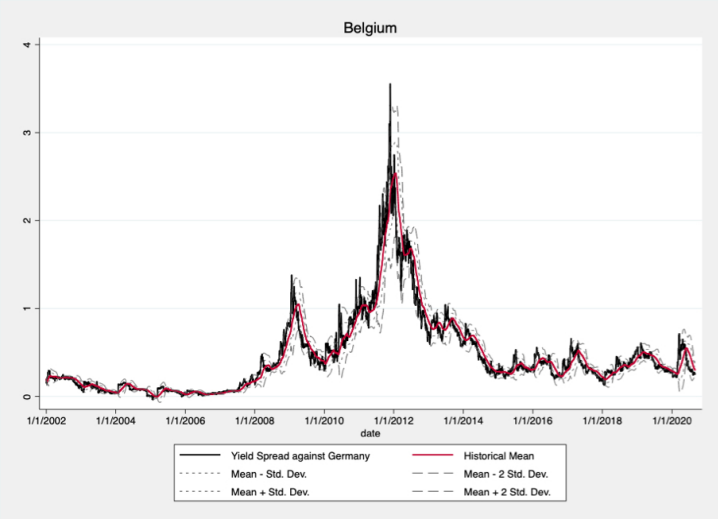


(a) Overview of Stress periods in Austria

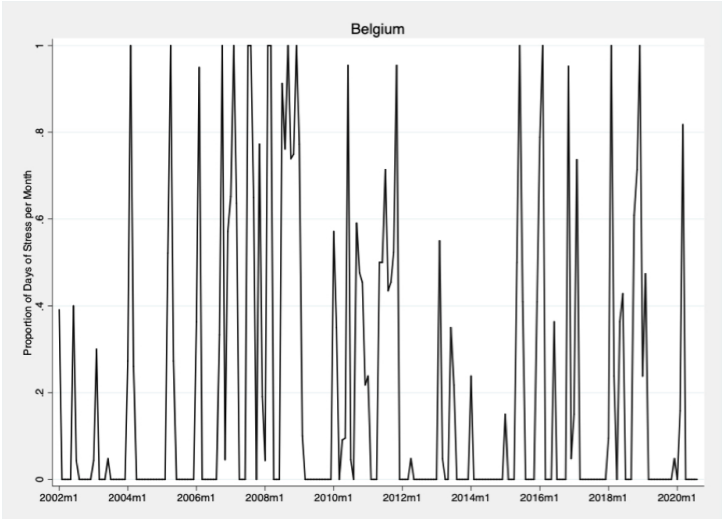


(b) Proportion of Days of Stress per Month in Austria

Figure A.1: Financial Stress in Austria 2002-2020

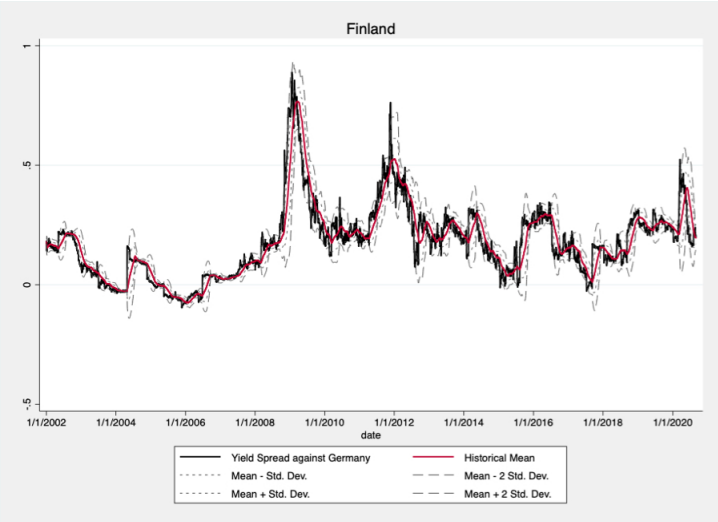


(a) Overview of Stress periods in Belgium

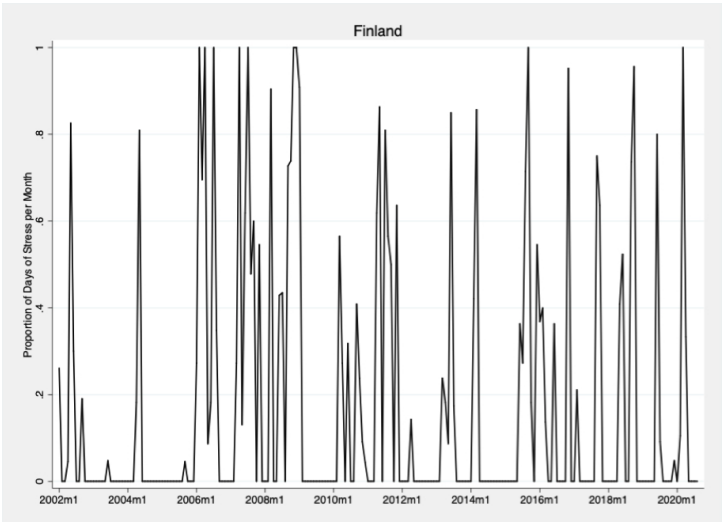


(b) Proportion of Days of Stress per Month in Belgium

Figure A.2: Financial Stress in Belgium 2002-2020

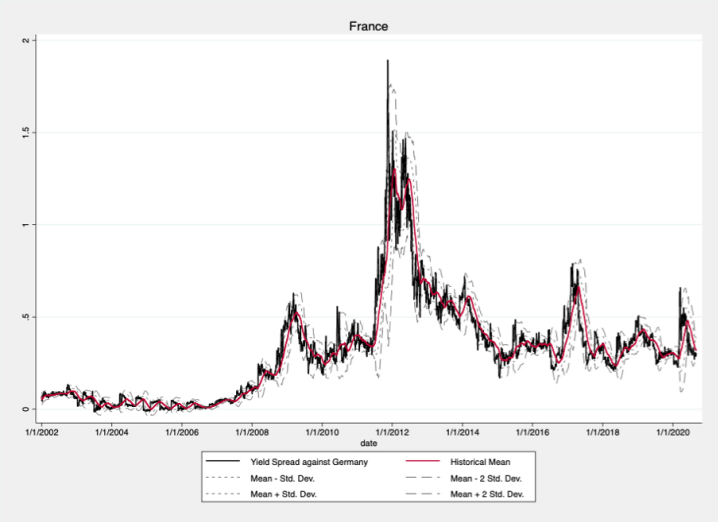


(a) Overview of Stress periods in Finland

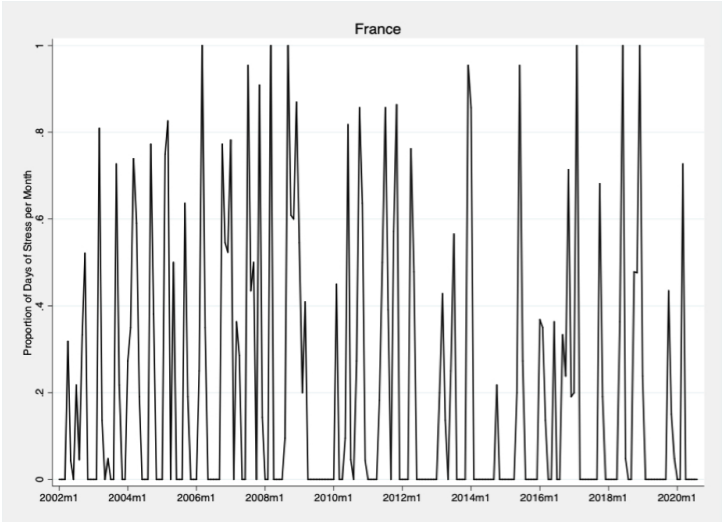


(b) Proportion of Days of Stress per Month in Finland

Figure A.3: Financial Stress in Finland 2002-2020

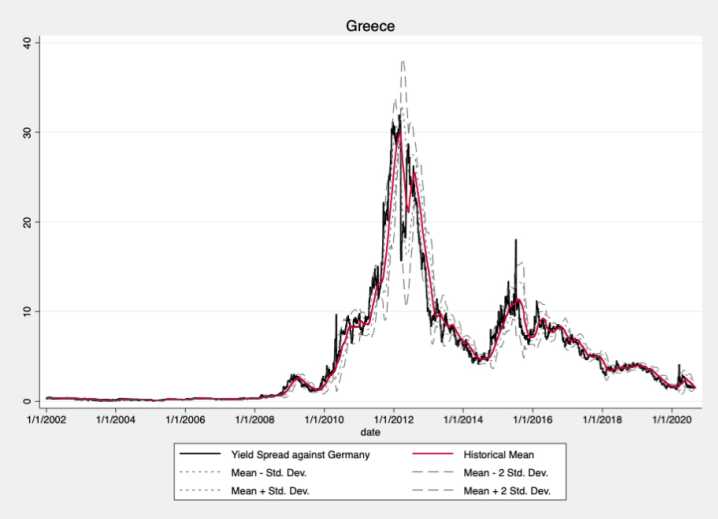


(a) Overview of Stress periods in France

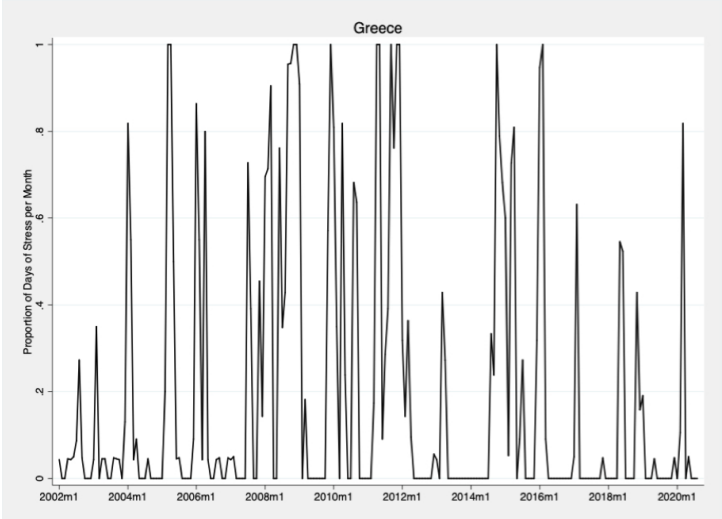


(b) Proportion of Days of Stress per Month in France

Figure A.4: Financial Stress in France 2002-2020

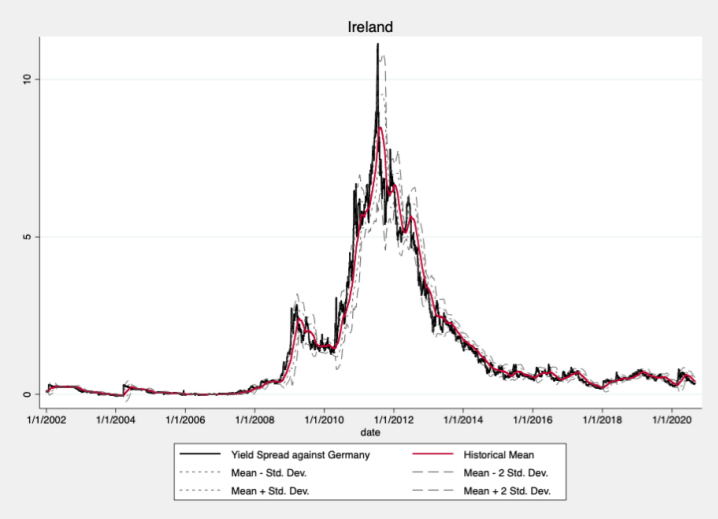


(a) Overview of Stress periods in Greece

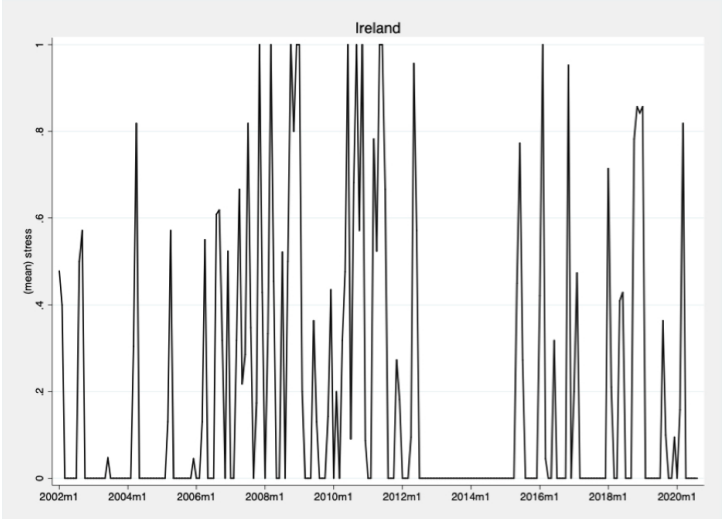


(b) Proportion of Days of Stress per Month in Greece

Figure A.5: Financial Stress in Greece 2002-2020

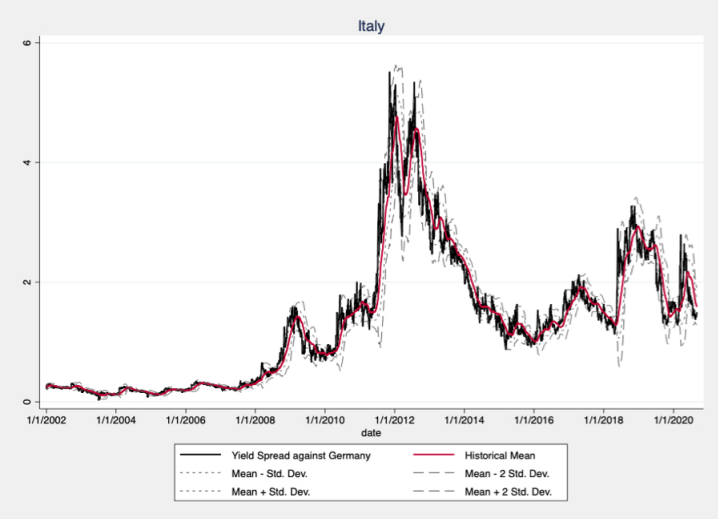


(a) Overview of Stress periods in Ireland

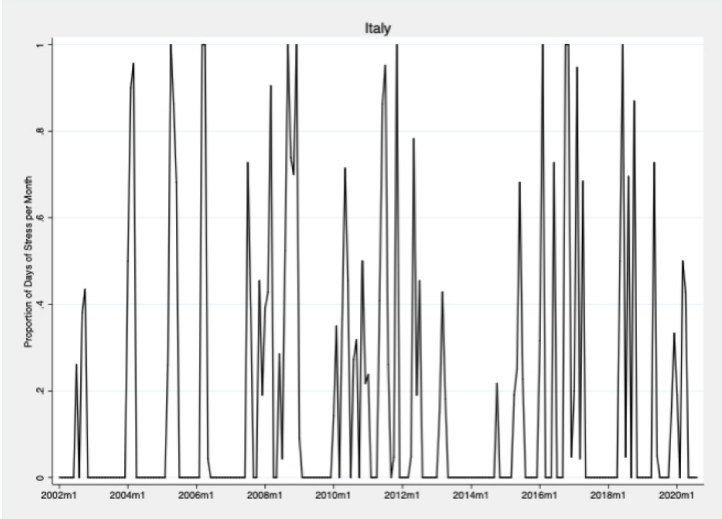


(b) Proportion of Days of Stress per Month in Ireland

Figure A.6: Financial Stress in Ireland 2002-2020

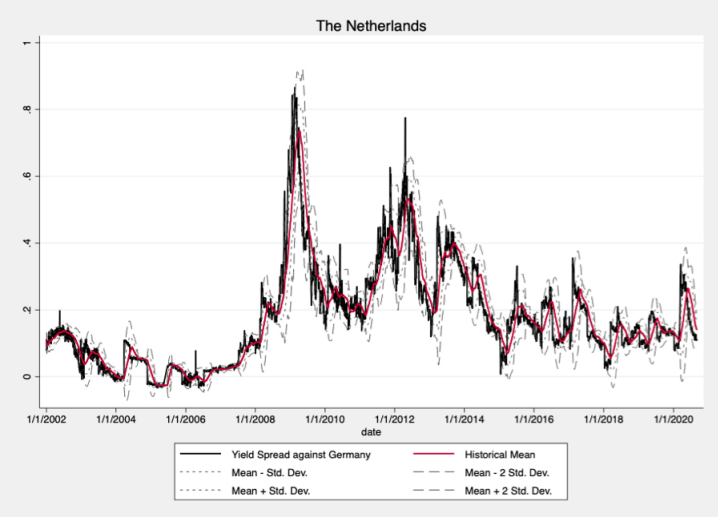


(a) Overview of Stress periods in Italy

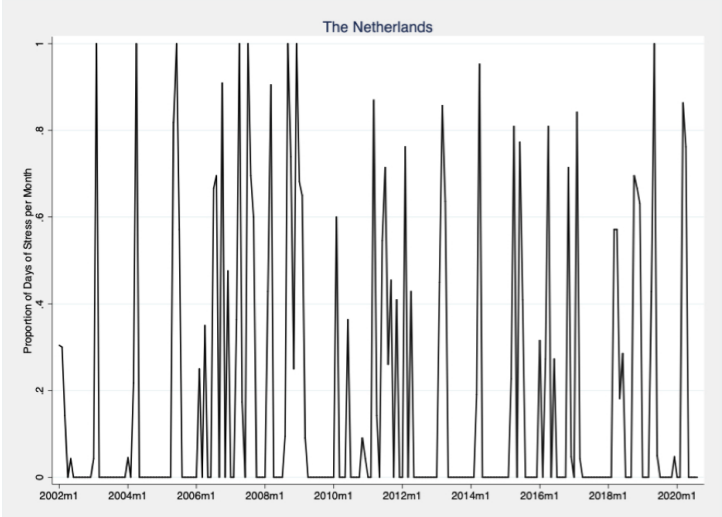


(b) Proportion of Days of Stress per Month in Italy

Figure A.7: Financial Stress in Italy 2002-2020

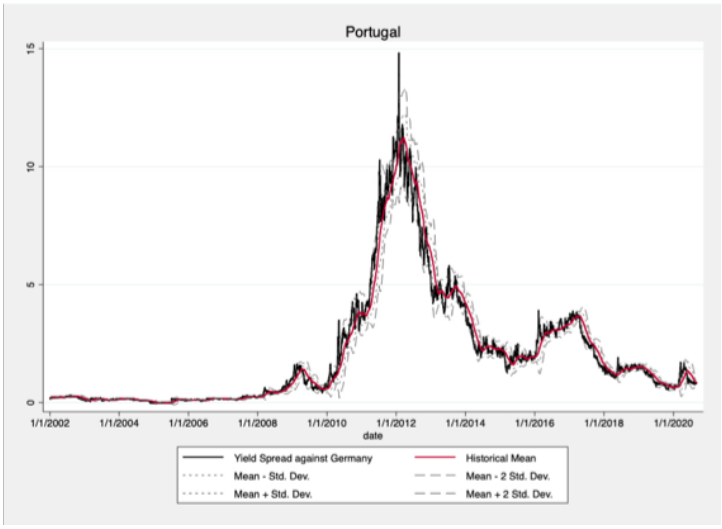


(a) Overview of Stress periods in the Netherlands

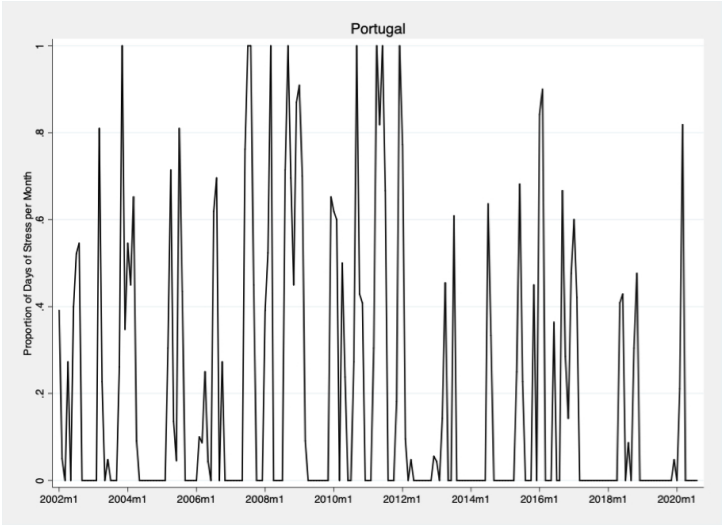


(b) Proportion of Days of Stress per Month in the Netherlands

Figure A.8: Financial Stress in the Netherlands 2002-2020

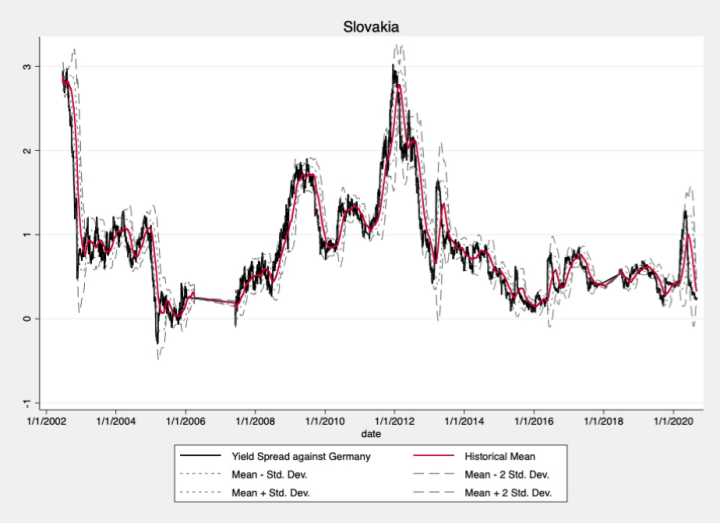


(a) Overview of Stress periods in Portugal

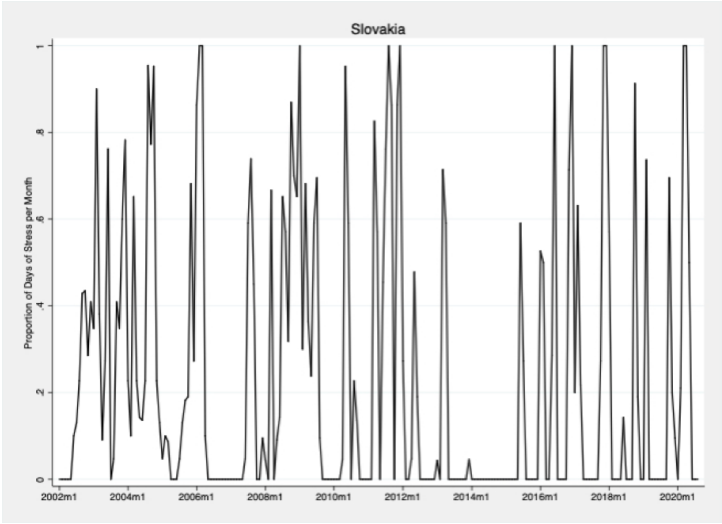


(b) Proportion of Days of Stress per Month in Portugal

Figure A.9: Financial Stress in Portugal 2002-2020

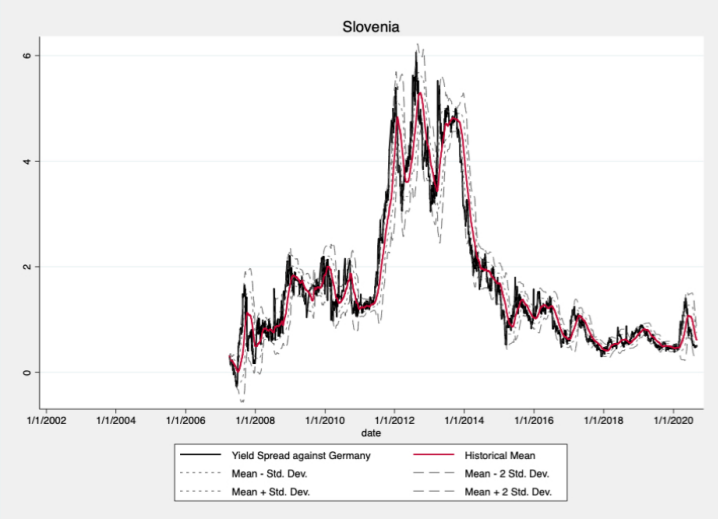


(a) Overview of Stress periods in Slovakia

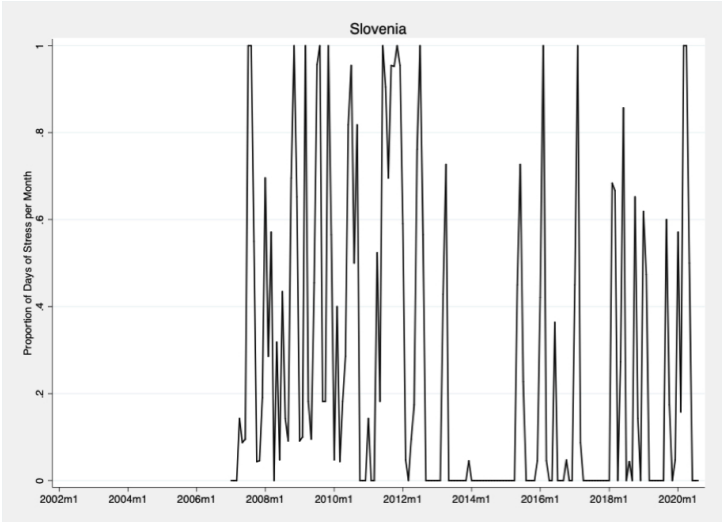


(b) Proportion of Days of Stress per Month in Slovakia

Figure A.10: Financial Stress in Slovakia 2002-2020

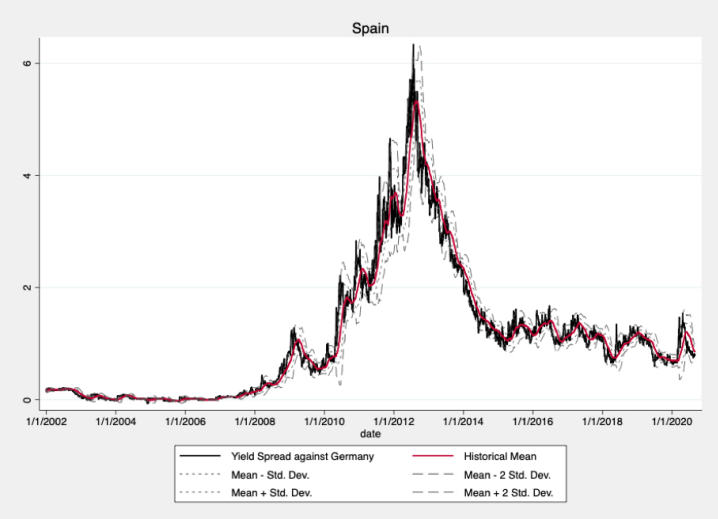


(a) Overview of Stress periods in Slovenia

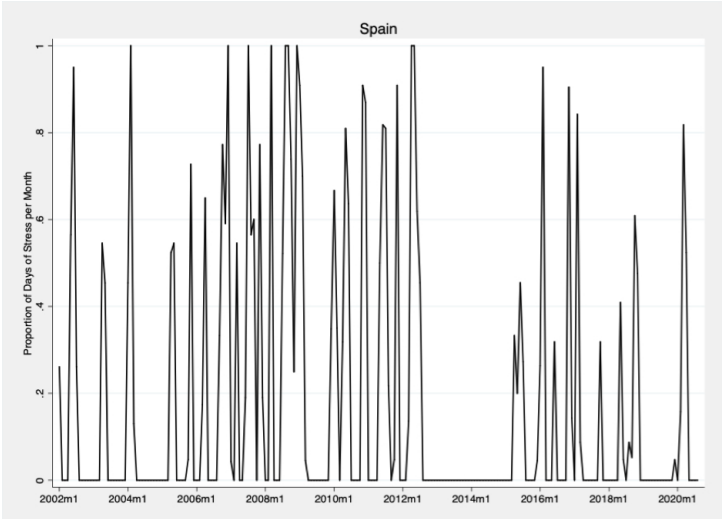


(b) Proportion of Days of Stress per Month in Slovenia

Figure A.11: Financial Stress in Slovenia 2002-2020



(a) Overview of Stress periods in Spain



(b) Proportion of Days of Stress per Month in Spain

Figure A.12: Financial Stress in Spain 2002-2020

Table A.2: Description of Portuguese Stress Periods[15]

Episode	Date	Description
1	10 - 22 Jan 2002	European Commission warns that it is to recommend the issue of an early warning after it becomes apparent that both Portugal and Germany would deviate from the Maastricht deficit threshold of 3% of GDP.
2	12 Feb 2002	Yields rise in expectation of ECOFIN's decision of whether to issue an early warning. Eventually, it does not follow through with it as Portugal and Germany review their consolidation plans and medium-term targets.
3	10 – 17 Apr 2002	UK Prime Minister Tony Blair proposes a referendum on whether the country should join the Euro. The idea is met with resistance, as a number of Labour MPs created a group called Labour Against the Euro (LATE).
4	14 – 20 Jun 2002	News that France is likely to miss the Stability and Growth Pact's demand that the countries' budgets should be balanced by 2004 raises questions on the credibility of the euro. The slow economic growth experienced by several EMU countries as Portugal, France, Germany and Italy leads them to present budget deficits similar or even crossing the 3% threshold. Discussions on the EU's most ambitious enlargement (scheduled to 2004) are stalled on divergences related to the fight against illegal immigration and the funds to attribute to eastern countries' farmers. ECB's prediction for EMU inflation is revised upwards, suggesting that it is likely to raise eurozone interest rates.

[15]News reports sourced from *Financial Times*, *Reuters* and *Jornal de Negócios*

Episode	Date	Description
5	26 Jun - 08 Jul 2002	Prime Minister Durão Barroso, just elected, officially reveals in a speech that Portugal holds a deficit of 3.9% of GDP for 2001, officially becoming the first country in the EMU to be in breach, which exposes it to the possibility of sanctions if the Excessive Deficit Procedure (EDP) is launched, should they be unable to reduce their deficit by the end of 2003. Fines could go up to 0.5% of GDP and/or the withholding of access to EU's cohesion funds.
6	24 Jul – 01 Aug 2002	This figure is revised to 4.1%, prompting the European Commission to declare its intention to write a report and set the EDP in motion.
7	05 – 19 Aug 2002	WorldCom accounting scandal and bankruptcy.
8	07 Mar – 07 Apr 2003	Portugal's involvement in the war with Iraq: U.S. President George W. Bush, Spanish Prime Minister José Maria Aznar, British Prime Minister Tony Blair and Prime Minister Durão Barroso meet in Terceira, Azores to finalize an agreement on the invasion and occupation of Iraq. Concerns about a potential war with Iraq lead European yields to rise.
9	17 Jun 2003	Little consensus on the proposed European Constitution, as the UK vetoes the first draft because it feels it weakens its ability to resist majority voting in key areas.
10	24 Oct – 10 Dec 2003	Both Germany and France ran budget deficits over the 3% of GDP ceiling, Germany with its biggest budget deficit since WWII. The credibility of the Euro is once again questioned as no fines are imposed on either country. Political turmoil ensues.

Episode	Date	Description
11	15 Jan – 12 Feb 2004	The European Commission launched legal action against national finance ministers over their failure to sanction Germany and France for breaking the Stability and Growth Pact. This prompts discussion on whether or not the best option would be to reform the pact rather than risking antagonizing two of the Euro's largest economies.
12	11 Mar – 02 Apr 2004	Madrid Terrorist Attacks.
13	22 Mar – 25 Mar 2005	José Sócrates takes over as Prime-Minister after President Jorge Sampaio dissolved the former government on the grounds of political instability. Several EU countries start presenting concerning economic statistics on unemployment levels and slow growth.
14	29 Mar – 06 Apr 2005	Spreads of several countries against the German Bund start diverging ahead of the French referendum on the European Constitution as investors are worried about the prospect of a rejection. Portugal sets a date to hold its own referendum but it is delayed with the fall of the government and for other legislative reasons.
15	14 – 22 Apr 2005	Prime Minister José Sócrates announces a public deficit of over 6%. This clashes with the former office's prediction of a 2% public deficit. Sócrates says the former prediction of the government of Santana Lopes lacked credibility.
16	26 - 27 Apr 2005	Yields rise in fear of austerity measures being planned to tackle the 6.8% deficit.
17	29 Apr - 04 May 2005	

Episode	Date	Description
18	15 Jun 2005	The rejection of the European Constitution at referendums in both France and the Netherlands increases yields on periphery countries, while yields on Dutch and French bonds don't show any significant response.
19	07 Jul – 12 Aug 2005	London Metro Bombings. Standard & Poor's downgrades Portugal's rating on 27 Jun 2005. Fitch reduced its outlook to negative. European Commission offers once again a recommendation on the excessive deficit situation felt in Portugal. According to *Financial Times*, it appears investors have reawakened given the deterioration of public finances in the weakest EMU countries.
20	23 – 24 Feb 2006	ECB President Jean-Claude Trichet raised warnings about inflation following signs that the European economy is picking up, putting several Eurozone countries on alert that the ECB would raise its benchmark interest rate several times during the year. During this period, the ECB raised its repo rate four times: in early March, June, August (coinciding with a raise in interest rates by the Bank of England as well) and in October. Additionally, in early July, General Motors annonced it's intention to shut down operations in its van factory in Azambuja by December, despite pleas by prime minister José Sócrates. It was the main employer in the region.
21	14-17 Apr 2006	
22	07 Mar 2006	
23	24 Mar 2006	
24	03 - 04 Apr 2006	
25	14-17 Apr 2006	
26	20 Apr 2006	
27	01 May 2006	
28	13 Jul – 22 Aug 2006	
29	04 - 11 Oct 2006	

Episode	Date	Description
30	05 – 14 Sep 2007	The subprime mortgage crisis seemingly spreads worldwide as several banks in Europe announce they will no longer rescue real estate funds in need. The ECB attempts to circumvent this by injecting liquidity into credit markets to ease the pressure of countries that may have difficulties obtaining credit, coordinating with the central banks of the United States, Australia, Canada and Japan for the first time since 9/11. Fears of a future recession in the U.S. spark.
31	21 – 31 Jan 2008	Emergency interest rate cuts by the U.S. federal reserve. Eurozone bond markets respond with extreme volatility as they wait for an ECB policy response.
32	15 Feb – 31 Mar 2008	Bear Stearns Crisis: collapse of Bear Stearns' hedge funds, a U.S. investment bank in the mortgage market. Yields across the Eurozone only start decreasing after the bank's rescue (Mar 16).
33	11 Aug – 13 Oct 2008	The collapse of investment bank Lehman Brothers (Sep 15) and of U.S's largest insurance company AIG (Sep 16) creates concerns over the global economy and health of the financial sector, as many European hedge funds and insurance groups sold protection to Lehman Brothers. It is expected that governments will be forced to recapitalize their banks, leaving countries like Portugal (with a current account deficit of 11% of GDP) with more difficulties in funding.
34	23 Oct – 13 Nov 2008	Portugal nationalizes Banco Português dos Negócios, after it accumulated losses of €700 Million and is at risk of not being able to meet payments.

Episode	Date	Description
35	04 Dec 2008 – 06 Jan 2009	Banco Privado Português receives a capital injection as a result of liquidity difficulties given the economic context. Moody's gives Portugal a negative outlook.
36	12 Jan – 03 Feb 2009	Standard & Poor's strips Spain of its AAA rating, Greece to A- and threatens a downgrade on Portuguese rating citing the deterioration of their public finances. On Jan 21 the rating is indeed downgraded.
37	12 Feb – 03 Mar 2009	Euro area yields surge in worries over the cost of bailing out banks and stimulating their economies as a recession becomes apparent. Credit markets respond disappointingly to the U.S. financial stability plan and in expectation of a decision by the Federal Reserve whether or not to buy U.S. government debt.
38	08 – 28 Dec 2009	Following the burst of a housing bubble in Dubai that leaves it unable to serve its debt, fears start spreading that the same might happen to Greece as it declares a revised public deficit of over 12%, exceeding over 4 times the EU's threshold (Oct 21). International financial markets start responding to Greece's deficit reveal when Fitch, Moody's and Standard & Poor's all downgrade Greek sovereign debt (starting on Dec 8). Spain's outlook is revised from Stable to Negative.

Episode	Date	Description
39	13 Jan - 16 Feb 2010	Portugal announces a budget deficit of 9.3%. Bond markets in Portugal, Spain and Ireland come under pressure because of their weak key economic indicators. After the Greek government announced its plans to tackle its debt levels, Portugal experiences a mass sell-off of government bonds for its lack of action. A bond auction had to be scaled back. European Commission publicly condemns Greece for deliberately misreporting and providing false statistics about its public finances. Fitch maintains its negative outlook on Portugal's sovereign debt, claiming that a downgrade of its rating is also likely.
40	16 Apr – 07 May 2010	Talks on Greece's rescue package begin: Greece signals that it is to make a formal request for financial assistance once terms are negociated. Germany alternates between offering conditioned help and threatening expulsion from the Euro for the members who do not comply with the Stability and Growth Pact. Portugal's bond yields rise on fears that it may have trouble repaying its debt. Greece's budget deficit is revised higher, to 13.6%. Moody's downgrades Greece's debt by one notch while Standard & Poor's downgrades it to junk status as the Greek-German spread surpasses 1,000 bp, sparking fears on Greece's exit from the Euro.

Episode	Date	Description
40	16 Apr – 07 May 2010	On Apr 23, Greece officially requests financial assistance. On May 2, a €110 billion package is agreed on, and on May 6 the Greek government approved the harshest program of fiscal adjustment set of austerity measures since the end of WWII in order to ensure the aid package. Protests of thousands ignite on the streets. Standard & Poor's downgrades both Spain and Portugal (Portugal by 2 notches). Ireland skips a bond auction.
41	24 Aug – 13 Oct 2010	Ireland announces the rescue of the Anglo-Irish Bank. Fitch downgrades Ireland's sovereign credit rating. German Chancelor Angela Merkel warns that debt holders should be forced to take losses as part of debt-restructuring, further leading investors to avoid buying bonds from periphery countries.
42	04 – 16 Nov 2010	Portuguese Parliament passes an austerity budget, cutting public spending and increasing VAT, widely unpopular measures. Ireland's Finance Minister Brian Lenihan said Ireland's public deficit would be over 11.9% and that rescuing the Ango-Irish bank would likely lead the net debt level to surpass 100% of GDP. Finance minister Fernando Teixeira dos Santos admits there is a high risk of needing an emergency aid. East Timor offers to buy Portuguese sovereign bonds in order to help.

Episode	Date	Description
42	04 – 16 Nov 2010	Yields rise in response to the Franco-German proposal for a rescue mechanism, abandoning the no-bailout clause of the Maastrict Treaty. Speculation around Portugal being in line for an aid package rise, both the ECB and Prime Minister José Sócrates dismiss the need for Portugal to require financial aid because its debt and deficit levels are lower and it has not suffered a property crash like Ireland. Standard & Poor's, as well as Moody's, downgrade Ireland's credit rating.
43	23 Mar - 13 May 2011	Moody's, Fitch and Standard & Poor's, all downgrade Portugal's rating. Standard & Poor's downgrades it twice in a single week. Yields rise in Portugal ahead of an austerity budget vote to avoid a bailout, a sign of investors' concerns on the country's ability to serve its debt. The plan is rejected and Prime Minister José Sócrates resigns. An Eurosceptic Finish party publicly claims it cannot support any financial assistance provided to Portugal. LCH.Clearnet, one of the largest interest rate swaps clearers in the world, issues a statement where Portuguese bonds would no longer be eligible as collateral for loans. Portugal officially requests financial assistance. Talk abounds on a potential Greek debt restructure.
44	20 May – 20 Jul 2011	Portugal's request is approved and it is set to receive a package totaling €78 billion.

Episode	Date	Description
44	20 May – 20 Jul 2011	More austerity packages are signed in Greece (Jun 29), accompanied by violent protests outside the parliament building and across several other Greek cities. Its rating keeps getting downgraded. Standard & Poor's gives it its lowest status possible on Jun 13. Yields in Portugal rise further as talk abounds that Greece might be the first country to leave the Euro, as a second bailout package is agreed with the Troika (€ 120 billion). Moody's downgrades both Portugal's and Ireland's rating to junk status. Signing of the treaty for the European Stability Mechanism.
45	25 Nov 2011 – 06 Jan 2012	Additional legislation is proposed to strengthen budgetary monitoring. Common issuance of sovereign bonds across the Euro area is proposed for the first time, the so called Eurobonds. Yields rise in Spain as its yields surpassed Greece's on the 3-month bond. Italy's yield curve inverts. Six pack enters into force, and the first Long Term Refinancing Operation (LTROs) takes place.
46	16 Jan – 02 Feb 2012	Yields rise unprecedentedly for Spain, Italy and Belgium, and for the first time, they rise significantly for AAA rated countries as well. Standard & Poor's downgrades 9 EMU members, citing their inability to collectively respond to the crisis. Standard & Poor's downgrades the European Financial Stability Facility, as well.

Episode	Date	Description
46	16 Jan – 02 Feb 2012	Greece names a list of over 4 100 Greek citizens that owe over € 14.9 billion in unpaid taxes to the government, which is more than the € 14.5 billion bond payment the country has to make until Mar 20 (which it will be unable to meet). Tensions in the relationship between the country and its creditors persist over talks of a debt write-off.
47	06 Apr 2012	A Greek man takes his own life in front of the Greek parliament as a protest against austerity, and sparks further protests in Athens. Yields on Spanish and Italian bonds keep rising as investors prefer less risky assets such as US or German government bonds, following a disappointing bond auction in Spain.
48	31 Dec 2012 – 01 Jan 2013	In a report, the EU Commission states that Portugal's bailout program requires strict austerity measures to re-enter financial markets, as its political setbacks and weaker-than-expected growth leave it on track to miss its next bailout review.
49	27 Mar – 12 Apr 2013	Cyprus becomes the first country to limit capital movements (withdrawls, transfers, credit card transactions), after fears of a bank run as the ECB threatened to halt emergency liquidity assistance to the country's two largest banks if they fail to agree on a plan for its bailout. Corruption scandals in Spain as well as failed elections in Italy raise the yields on Portuguese debt.

Episode	Date	Description
49	27 Mar – 12 Apr 2013	Portuguese Supreme Court of Justice annuls austerity measures that will have a significant budget impact.
50	02 Jul – 19 Jul 2013	U.S. Federal Reserve announces its intention to cut its injections of cheap money that investors often used to buy risk bonds. Greek Parliament agrees to further austerity measures as a condition to another tranche of the ongoing EU-IMF bailout, including tax reforms, wage cuts and other budget cuts. Labor unions call for general strikes in protest. Portugal's finance minister Vítor Gaspar and foreign minister Paulo Portas both resign. Paulo Portas steps up as deputy prime minister.
51	08 – 25 Jul 2014	Luxembourg's justice authorities begin an investigation into 3 holding companies of Banco Espírito Santo.
52	05 – 13 Aug 2014	Portugal rescues Banco Espírito Santo.
53	22 May – 19 Jun 2015	Eurozone's bond yields rise when it becomes clear that the Greek government will miss its € 1.6 billion payment to the IMF when its bailout expires on Jun 30, marking the first time a developed country defaults to the IMF. Negotiations between the Greek government and its creditors remain turbulent after the IMF negotiators walked out of the bailout talks and Prime Minister Tsipras proposed a referendum on the EU proposals.
54	02 – 09 Jul 2015	Jun 28: Amid concerns that Greece will not be able to stay in the Euro, the Greek government limits bank withdrawals to avoid financial collapse.

Episode	Date	Description
54	02 – 09 Jul 2015	Jun 30: Greece defaults on its payment to the IMF. Jul 5: Greek referendum on a bailout agreement, which is rejected and leads to the resignation of Finance Minister Yanis Varoufakis. Prime Minister Alexis Tsipras goes forward with an agreement anyway after discussions that Greece might be forced to leave the euro if any deal fails to be struck.
55	05 – 17 Nov 2015	Inconclusive government elections in Portugal. Yield surge as a left-wing political coalition ("Geringonça") steps into power, aiming to reverse harsh austerity. Threat of a credit downgrade by DBRS which would stop Portugal from accessing the ECB's Quantitative Easing Program.
56	07 Jan – 25 Feb 2016	Portuguese yields remain volatile as financial markets worry over a potentially unstable government.
57	13 – 17 Jun 2016	Yields across the Euro Area rise after approval on U.K.'s referendum to leave the EU.
58	24 – 28 Jun 2016	
59	13 Sep – 10 Oct 2016	Threat of a credit rating downgrade by DBRS, following a missed a budget deficit forecast target.
60	17 – 21 Nov 2016	Investors sell-off Portuguese bonds amid renewed fears of political fragility because of its high debt level and slow growth rate, after the European Commission warned that it was not complying with stipulated deficit limits.

Episode	Date	Description
61	16 Dec 2016 – 12 Jan 2017	Fears over potential U.S. protectionist policies in trade following Donald Trump's election as President of the United States.
62	26 Jan - 10 Feb 2017	The IMF maintains that Greece's debt has reached unsustainable proportions and that the budget cuts EU creditors demand will hamper Greece's economic growth. Greece disputes "the IMF's absurd demands".
63	18 May – 01 Jun 2018	Political turbulence in Italy: after an election resulted in a hung parliament, a populist, Eurosceptic coalition takes power and the political uncertainty causes mass a sell-off of Italian bonds.
64	05 – 14 Jun 2018	Spanish parliament votes to replace Prime Minister Mariano Rajoy with Pedro Sánchez in a vote of no-confidence after a corruption scandal in the centre-right party.
65	20 – 31 Aug 2018	Fear of contagion from the Turkish Currency Crisis (President Erdogan decides to concentrate decision-making power), due to exposure to Turkish banks, weighs heavily on periphery countries, especially due to the high demand for German Bunds for its safe-haven status. Italy's new government begins budget discussions.

Episode	Date	Description
66	18 – 26 Oct 2018	Italian politicians argue that it is unfair for the EU Commission to single out Italy when all periphery nations have concerning budgetary positions. Moody's downgrades Italy's rating by one notch while Standard & Poor's leave it but change its outlook to negative.
67	09 – 23 Nov 2018	The EU Commission issues a warning that Italy's deficit has breached the threshold of 3% of GDP, according to Commission calculations and against what the Italian government stated. Italian government goes against EU Commission indications with a budget that aims to sharply increase public spending. Investors start fearing the "diabolic loop" once again, as Italy's debt is much higher than Greece's was before the beginning of the crisis.
68	31 Dec 2019	Mass sell-off of Eurozone sovereign bonds causes yields to increase as a result of an outbreak of optimism in market sentiment.
69	25 Feb – 25 Mar 2020	COVID-19 pandemic and economic lockdown.

Table A.3: Rating Classifications

	Moody's	Standard & Poor's	Fitch	Numerical Scale
Investment Grade	Aaa	AAA	AAA	21
	Aa1	AA+	AA+	20
	Aa2	AA	AA	19
	Aa3	AA-	AA-	18
	A1	A+	A+	17
	A2	A	A	16
	A3	A-	A-	15
	Baa1	BBB+	BBB+	14
	Baa2	BBB	BBB	13
	Baa3	BBB-	BBB-	12
Speculative Grade	Ba1	BB+	BB+	11
	Ba2	BB	BB	10
	Ba3	BB-	BB-	9
	B1	B+	B+	8
	B2	B	B	7
	B3	B-	B-	6
	Caa1	CCC+	CCC+	5
	Caa2	CCC	CCC	4
	Caa3	CCC-	CCC-	3
	-	CC	CC	2
	-	C	C	1
	Ca	SD	DDD	
	C	D	DD	
	-	-	D	

Table A.4: Unit Root Test Results

Variables	Im-Pesaran-Shin Test				
	Statistic	Order of Integration	Replacement	Statistic	Order of Integration
Credit Rating	-0.824	I(1)	Lagged Downgrade	-68.043***	I(0)
VIX	-7.920***	I(0)	-	-	-
EUR/USD Exchange Rate	-2.682***	I(0)	-	-	-
Interbank Tensions	-1.904*	I(1)	$\Delta\, IT$	-71.606***	I(0)
U.S. Yield	-1.545	I(1)	$\Delta\, U.S.\ Yield$	-73.672***	I(0)